ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XLVII. No. 16.

TABLE OF CONTENTS:

(20 *pages*; *no inset.*)

ENGINEERING NEWS OF THE WEEK 301
A Small Water Power Electric Transmission Plant for Local Lighting Service; Utah County, Utah (illustrated) 302
Notes on Lost Head in Water Supply Systems 303
Defective Bridge Construction in the Prairie States (illustrated.) 304
An 8-in. Hydraulic Gate Valve on a Detroit Water Main Supplying River Rouge, Mich. (illustrated). 306
Some Needed Reforms in the Conduct of River and Harbor Work 306
Suggestions for a More Uniform Practice in Fixing the Length of Spiral Curves 308
Diagram for Determining Size of Rainwater Conductors and Gutters for Buildings 309
Opportunities for Engineers in the New Possessions of the United States 309
Consolidation of Street Railway Franchises at Antwerp, Belgium 309
Book Reviews 313
Intermittent Filtration of Sewage at Brockton, Mass., during 1901 313
Proposed Light Refuse Crematory for New York City (illustrated) 314
The Coal Fields of the United States 315
The Decision in the Dayton Electrolysis Suit 316
A Simple Method of Calculating Continuous and Constrained Beams (illustrated) 317
A Locomotive for Burning Lignite Fuel 317
Economical Power Development with Superheated Steam in a De Laval Steam Turbine 318
The New York Rapid Transit Ry., VII. (illustrated) 318
EDITORIAL NOTES 310
The Decision in the Dayton Electrolysis Suit—Needed Reforms in the Conduct of River and Harbor Work—An Important Water Rights Decision.
EDITORIAL:
Water Purification in the United States 310
LETTERS TO THE EDITOR 312
Priming Centrifugal Pumps—The Relative Cost of Macadam Roads at Port Huron, Mich., and Hudson, N. Y.—Notes and Queries.

BIDS FOR THE MAIN DAM for the new water supply of Jersey City, N. J., will be received on April 21 by the Jersey City Water Supply Co., of Jersey City, N. J., as noted more fully just below.

THE PRESENT STATUS of the Jersey City water supply contract is given in some detail in the following letter (dated April 14) to this journal from Mr. Edlow W. Harrison, M. Am. Soc. C. E., Chief Engineer of the Jersey City Water Supply Co.:

The Jersey City Water Supply Co., which holds the contract made between Jersey City and Mr. P. H. Flynn, of Brooklyn, for the new water supply of 50,000,000 gallons per day, with a capacity in watershed and storage reservoir sites of 70,000,000 gallons per day, from the Rockaway River watershed, and which, up to April 1, last, was controlled by Mr. Flynn and his associates, has, by transfer of stock, passed under the control of the New Jersey General Security Co., who also hold the controlling interest in the East Jersey Water Co.; Mr. Flynn and his associates holding a residuary interest in the contract, and Mr. John McCarty, and Mr. Flynn, himself, remaining in the directory. The new President of the company is Mr. Edmund Le B. Gardner; the Vice-President, Mr. George F. Baker, of the First National Bank of New York; the Chief Engineer, Mr. Edlow W. Harrison, M. Am. Soc. C. E., of Jersey City, and the Resident Engineer, Mr. W. R. Fuller, M. Am. Soc. C. E., now of Paterson, N. J. The reorganized company has procured from Jersey City a modification of the contract which fixes the time for completion of the works, Dec. 25, 1903, in consideration of which the East Jersey Water Co., now supplying the city with a temporary supply of water under a contract which expires in October of this year, extends its contract at the same price until the new works are finished, and agrees that if the new 72-in. steel pipe is completed between the point where the new line crosses its pipe in Upper Montclair, and the Jersey City reservoir, to send the water through this pipe, and deliver at the head of 210 ft. called for by the Flynn contract, in the fall of this year. This will save pumping at high service. The company proposes to sublet the building of the large dam at Boonton, containing upwards of 200,000 cu. yds. of masonry, and the printed specifications and plans for which will be ready for the bidders this afternoon (April 14). We expect to receive the bids April 21. We shall also sublet the preparation of the reservoir, the building of four miles of concrete and expanded metal conduit on the hydraulic grade, and the placing of the submerged pipe in the Hackensack and Passaic rivers. The Gillespie Co. already has a contract for the 17 miles of steel pipe required, of which about one-third has already been laid, and the Hudson Tunneling Co. has the contract for the long tunnel of 7,400 ft. through the Watchung Mountain, two-thirds of which has been opened. Under the Flynn control, a large amount of work, probably one-third of actual cost of the whole work on the dam, has been completed, consisting of nearly all the excavation; building of three miles of railroad between the dam and the quarry; the opening of a large quarry; the preparation of 16,000 yds. of granite ashlar ready to put in the work, and getting out, ready for laying, of between 30,000 and 40,000 yds. of rubble, besides the installation of crusher, derricks, compressor plants and other items necessary for the economical completion of a large work of this character. All of this work is to be turned over to the subcontractor, for his use, during the construction. The whole dam is to be completed by November, 1903, necessitating a record in the erection of rubble masonry structures, but the conveniences of getting out and handling the stone are such that we believe this can be done without any difficulty.

A WATER-STORAGE COMMISSION for New York State is provided for by a legislative act just signed by Governor Odell. The members, in part, are to be existing state officials. There will be a secretary, who will receive a salary of $2,000 a year.

A CONTRACT FOR A 60-IN. STEEL PIPE LINE, about eight miles long, has been let by Newark, N. J., to the T. A. Gillespie Co., 71 Broadway, New York city. Requests for bids for both steel and cast iron brought in four bids for each, as given in detail on p. 120 of our Supplement for March 27. The lowest bids under each plan, both from the Gillespie Co., were approximately $600,000 for steel and $1,000,000 for cast iron. All four bids for cast iron were very close to each other, there being only about $50,000 between the highest and the lowest. One of the bids for a steel pipe line was about $850,000.

200 MILES OF GOOD ROADS are to be built by the State of New York during the present season, and bids for the work are called for by the State Engineer, as noted in our advertising columns. The estimated cost of the work is about $1,500,000.

INTERSTATE WATER RIGHTS have been declared subject to the jurisdiction of the United States courts by the overruling of a demurrer to a suit brought by the state of Kansas against Colorado. Kansas, in behalf of both public and citizens' rights, has filed a bill for an injunction against the use by Colorado of water from the Arkansas River before it flows into Kansas. The U. S. Supreme Court allows the case to come to trial.

WATER SUPPLY AND WATER POWER schemes for Lockport, N. Y., have been numerous and varied for several years. The prospects for something more than agitation have been rendered more promising by (1) the passage by the State Legislature of a bill allowing the city to spend $5,000 for an investigation of the water supply question and $500,000, if the people so vote, for a water plant, and (2) by an agreement between the city and the Niagara, Lockport & Ontario Power Co., under which the city is to pay $50,000 a year for a domestic water supply, provided the company deposits $500,000 in a Lockport bank by July 1, 1902, and begins to construct a power canal by Nov. 1, 1902. We are indebted to Mr. Julius W. Frehsee, City Engineer of Lockport, for information regarding these two plans.

DAMAGES FOR WATER POLLUTION to the amount of $1,000 have been awarded in a jury trial in a county court against the American Copper Extracting Co., of Garfield, N. J. The company discharged wastes into the Rahway River. Suits for an injunction are likely to follow.

SLOW SAND FILTRATION EXPERIMENTS on the removal of odor and taste from water taken from the Ludlow reservoir and Jabish Brook for the supply of the city of Springfield, Mass., have convinced the State Board of Health that double filtration would be necessary to that end, at least during a portion of the year. The experiments extended from late in December, 1900, to Feb. 1, 1902, the analyses being made by the State Board of Health. An ordinary slow-sand filter, 5 ft. deep above the underdrains, with medium sand a little coarser than that in the Lawrence city filters, was operated during most of the experiment at a rate of 2,500,000 gallons a day. During the latter part of the test the rate was increased. This removed the objectionable odors, except during August and September, when the excessive amounts of organic matter in the reservoir water were accompanied by large numbers of anaboena, and the odor from the filtered water was nearly as bad as that from the unfiltered. A second filtration, at a much more rapid rate, removed the taste and odor. Although the experiments indicated that double filtration would make the Ludlow reservoir satisfactory when at its worst, the State Board of Health advised a gravity supply of unfiltered water from the Westfield River. This advice was largely due to the fact that, filtered or unfiltered, the present supply will be insufficient for more than ten years to come, so after a heavy expenditure for constructing filters, still more money would be required to supplement the supply.

THE PASSAIC VALLEY SEWERAGE COMMISSION will have as its fifth member Mr. Julius A. Lebuecher, of Newark, N. J. The names of the five original appointees were given in our issue of April 3, but one of them, Mr. Winston Garrison, declined to serve on finding that if he did so he must give up his position as a member of the Newark Street and Water Board.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Massachusetts Central division of the Boston & Maine R. R., at Wayland, Mass., on April 10. An eastbound freight train ran through an open switch into some cars standing on a siding at the freight house. In the ensuing wreck, the freight house was demolished, the engine wrecked and a number of cars destroyed. The engineer and a brakeman were killed.

A COUPLE OF FAST RUNS with a special train carrying President Cassatt were recently made on the Pennsylvania R. R., between Philadelphia and Jersey City, and an official bulletin of the time of the run has just been issued. We print it below and it will be seen to show a maximum speed of 90 miles an hour for the six miles between Princeton Junction and Monmouth Junction.

Miles.	Left Broad St., Philadelphia Station.	Extra No. 804, Mar. 23, '02. 1:12 p.m. Speed between stations, miles per hour.	Extra No. 850, Mar. 24, '02. 12:19 p.m. Speed between stations, miles per hour.
0.0	Broad St.	....	....
2.7	Mantua	29.5	32.4
5.4	Germantown Junction	54.0	54.0
9.2	Frankford Junction	57.0	65.1
13.2	Holmesburg Junction	80.0	87.3
23.4	Bristol	68.0	74.2
33.7	Trenton	77.2	72.7
43.4	Princeton Junction	72.7	83.1
49.4	Monmouth Junction	90.0	72.0
57.5	Millstone Junction	60.7	72.0
64.6	Metuchen	71.0	81.1
70.4	Perth Amboy Junction	81.9	73.3
75.7	South Elizabeth	85.0	67.0
79.4	Waverly	74.0	59.2
82.4	East Newark Junction	45.0	48.0
89.4	Jersey City	70.0	60.0
	Average speed	67.1	67.9
	Time elapsed	80 mins.	79 mins.

A BRIDGE REMOVAL was accomplished April 13 at Pittsburg, Pa., by the American Bridge Co. and the engineering force of the Pittsburg, Fort Wayne & Chicago Ry. The old bridge over the Allegheny River was moved about 25 ft. down stream (resting on timber extensions of the piers) to make room for the erection of a new double-deck structure, carrying the railway on the lower deck and an electric line on the upper deck. The ends of the spans were seated on rails carried by rollers on other rails laid on the piers and trestles, and the structure was moved by means of tackle and three hoisting engines. The bridge is 1,100 ft. long, and the track rails were not separated over the piers. The south end was moved first and then the north end. The entire work occupied only about seven hours.

THE LONDON UNDERGROUND ELECTRIC enterprises to be undertaken by Mr. Charles T. Yerkes are to be financed by the London and New York firms of the Speyers, with a capital of $25,000,000; the Old Colony Trust Co., of Boston, one of the members of the old syndicate formed for this purpose, is included in the new Underground Electric Railway Co., of London, Ltd. The main properties of this company will be the Metropolitan District Railway and Metropolitan Railway, which are to be changed from steam to electricity. It will also control the Baker Street & Waterloo Railway Co., the Brompton & Piccadilly Circus, the Great Northern & Strand and the Charing Cross, Euston & Hampstead railway companies. These lines will all be developed along American lines. Mr. Yerkes is the first chairman of the new company.

THE SYDNEY AND PORT DARWIN RAILWAY, across Australia, is being promoted by the National Association to Federalize the Northern Territory, of Melbourne, N. S. W. This association is endeavoring to secure a larger share of the mail, passenger and light freight traffic between Europe and Australia; and it thinks that the Siberian Railway can be utilized in this project, as 10,000 miles of the new route between Adelaide, Melbourne, Sydney, Brisbane and London, is now covered by railway. It believes this railway route will be quicker and cheaper than the all-water route, and proposes to add to it by a railway 2,247 miles long across Australia, to the north; of this total 563 miles are constructed, from Sydney to Bourke. The distance from Port Darwin to Port Arthur, at the end of the Siberian Railway, is 3,000 miles. The Association asks the Federal Government to take up this work and to complete it by 1905.

A NEW BRIDGE-FERRY is to be built at Nantes, France, to transport freight cars over the River Loire. The bridge will consist of two steel towers 487 ft. apart, connected by a horizontal track 162 ft. above the water. An inverted steel truck will run on this track and by cable-suspenders carry a ferry-platform 40 ft. square and having a maximum capacity of 60 tons. The estimated cost of the bridge is $190,000 and it will be completed in 1903. The ferry will also carry foot passengers, carts, etc., for which toll will be charged. The bridge is to be built under a patent owned by Mr. F. Arnodine.

OPEN-HEARTH STEEL, to the amount of 4,656,309 gross tons, was made in the United States in 1901, says the American Iron and Steel Association. This product is more than double that of 1898, which was 2,230,202 tons. Of the total for 1901, 3,504,763 tons were made in Pennsylvania; though 90 works in 14 states made steel of this class.

A SMALL WATER POWER ELECTRIC TRANSMISSION PLANT FOR LOCAL LIGHTING SERVICE, UTAH COUNTY, UTAH.

By W. P. Hardesty, C. E.*

The power development to be described is a good example of what can be done in the way of utilizing the natural fall of many mountain streams in the west for the benefit of neighboring settlements.

The American Fork River or creek rises near the summit of the Wasatch Mountains in Utah and flows west, discharging into Utah Lake, which is in Utah county, and 30 or 35 miles south of Salt Lake City. On the east side of the lake, in the Utah Valley and reaching back to the mountains, the country is well settled and has a number of important towns. At the north end of the valley are located the towns of Lehi, American Fork and Pleasant Grove. It was with the primary object of lighting these places that the Utah County Light & Power Co. was organized. This is a stock company, composed of residents of the locality who recognized the possibilities of water power development in the American Fork Creek. This creek runs through a deep gorge, or canon, for a distance of 10 miles from its head to the mouth of the canon, about 5 miles northeast of the town of American Fork. For about 1½ miles before reaching the mouth of the canon the fall is about 185 ft. per mile. It was resolved to utilize the fall of this portion, as the creek is much smaller above. Construction was begun in December, 1899, and the plant began running in December, 1900.

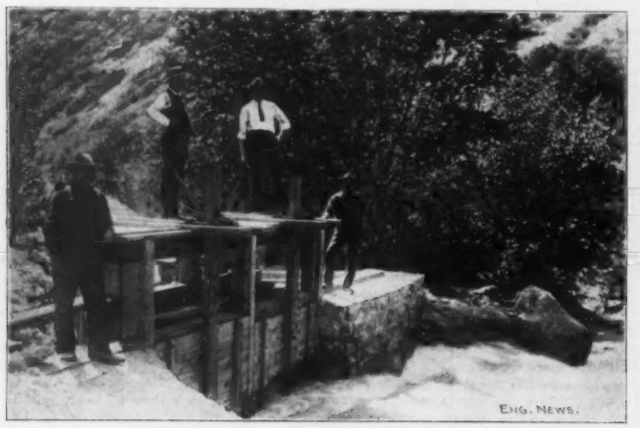


FIG. 1. VIEW OF HEAD-GATE AT DIVERSION OF AMERICAN FORK CREEK; UTAH LIGHT & POWER CO., UTAH.

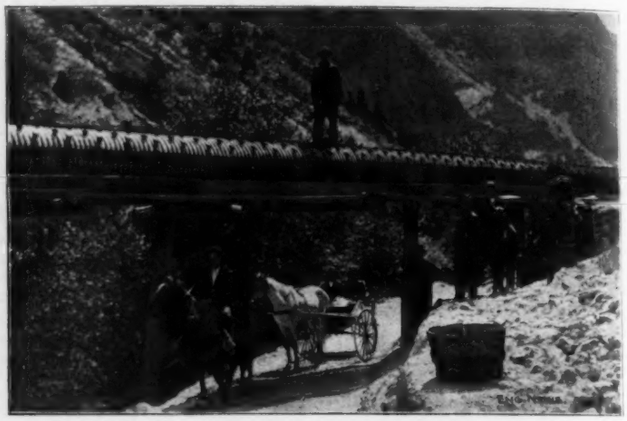


FIG. 2. VIEW OF WOOD STAVE PIPE LINE ON TRESTLE, UTAH LIGHT & POWER CO., UTAH.

The system consists essentially of a wooden stave pipe conveying water from the creek, along the bottom and side of the canon to a point opposite the power house, at the mouth of the canon, a riveted steel pipe leading down the steep slope to the power house; the machinery for the generation of water power and electrical power, and the transmission of the electric current to the towns where it is used.

Water is diverted from the creek through a wooden head-gate set between masonry abutments (Fig. 1), no dam being required. The water is then conveyed through a flume for a distance of about 100 ft. The lower end of this flume is elevated above the ground, to allow of discharging the water into a penstock. Leading from the foot of the latter is the 36-in. wooden pipe. This arrangement allows of a depth of about 6 ft. of water over the entrance to the pipe, which is abundant for entry and velocity heads. This arrangement is much superior to an attempt to provide the head directly at the diversion from the stream, which would require either a dam or the placing of the pipe head well below the level of the creek bed.

The pipe line follows near the bottom of the canon, along the creek and wagon road, for a distance of almost 3,000 ft. It then crosses to the north side of the creek and runs along the north side of the canon on a uniform supported grade of 10 ft. per mile. The fall of the pipe to where it leaves the creek is 131 ft., and it is 9 ft. more to the head of the steel pipe. The length of wood pipe is a little over 8,000 ft. The pipe is made of staves of Oregon fir, banded with steel bands. The staves are not of "clear" fir, but have many knots and other imperfections. They were milled from 2 × 6-in. stuff, dressing to 1¾ ins. thick and 5⅝ ins. wide on the outer circumference. The milling was done at the mouth of the canon. The bands are ½-in. in diameter, with a head at one end and a nut at the other. The threaded end is upset, and it has rolled threads. Ordinary cast-iron lugs are used. The spacing of the bands was figured for a safe strain of 15,000 lbs. per sq. in. It ranges from 12 ins. at the head to 2¾ ins. for the last ½ mile.

A light excavation or bench was made for the wood pipe, and on this 6 × 8-in. sills placed 6 ft. apart were laid. The pipe rests on these. A wooden "chock" shaped to the pipe is used on each side of the bottom, so that the pipe has an even bearing for nearly one-third of its circumference.

The line was located more with a view to save expensive work in grading than anything else. While the cost of this was kept down to $3,000, by using numerous sharp curves and by closely following a grade contour where the line lies on the hillside, it is probable that it would have paid to have spent considerably more to secure a more direct alinement and easier curves. Many of the curves have radii of less than 100 ft. Very little solid rock was removed in the grading. Dur[ing] the building of the pipe line it was the pra[ctice] to keep the portion constructed, up to within short distance of the workmen, filled with w[ater] turned in at the head. A temporary bulkhead [was] used to confine the water above it. The objec[t] this was to keep the wood soaked and so [pre]vent it from drying out, and to test the pipe [for] leaks. This scheme worked admirably. An[ample] time was thus secured to fix up all the w[eak] places before any dirt had been thrown over [the] pipe, and before the final test. The pipe is s[up]ported by a trestle where it crosses the creek a[nd] wagon road, Fig. 2.

The pipe was at first left uncovered, but the numerous small breaks resulting from rocks rolling down on to it finally led to its being partly covered, so that rocks would glance over it. Undoubtedly it would have been better in the long run if the pipe had been buried in a trench as the engineer desired.

At the end of the wood pipe is placed a 36-in. receiver. This has two outlets, each 24-in. in diameter and controlled by a 24-in. valve. All these are enclosed in a small frame house. Each outlet is designed to connect with a 24-in. steel pipe leading down the canon side to the power house. Only one of these has been constructed so far. This is of riveted steel plates, ¼-in. thick. The longitudinal seams are double-riveted and the circumferential seams are single riveted. The lengths of pipe were tested to 180 lbs. pressure at the factory. They were dipped in a preparation of maltha. The steel pipe is 325 ft. long. It rests on cross-pieces of wood. The first 206

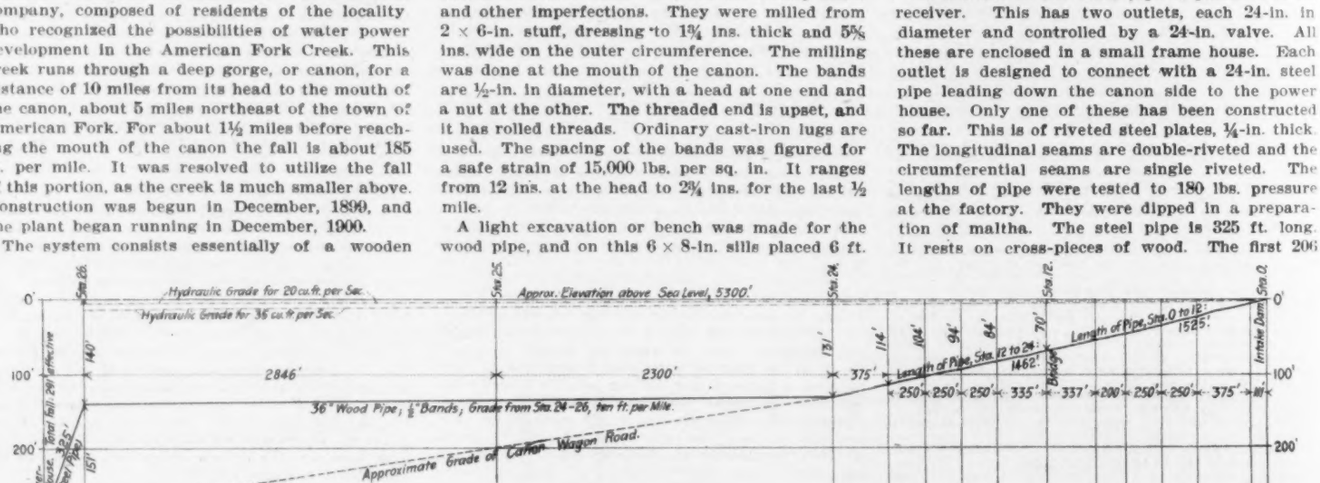


FIG 3. PROFILE OF PIPE LINE OF UTAH LIGHT & POWER CO., UTAH.

The fall in the pressure pipe is 151 ft., which added to the fall of 140 ft. in the wood pipe gives a static head of 291 ft. at the power house, referred to the intake. In the wood pipe it is calculated that the head consumed in friction will be 4 ft. for a delivery of 20 cu. ft. per second, and 12 ft. for 35 second feet. Fig. 3 is a profile of the pipe line.

From the description it will be seen that the

*Salt Lake City, Utah.

wooden pipe is far below the hydraulic grade line for nearly all its length. It is not merely a conduit that keeps just below the hydraulic grade as in the case of many power developments. To have kept anywhere near this would have thrown the line among the rock cliffs for much of its length. There is undoubtedly an advantage in the present location in that almost any velocity desired can be secured, allowing a very wide variation in the supply and manner of use at the power house. If the wood conduit were kept up to the hydraulic grade at the point of connection with the pressure pipe, any error in calculating the grade line for a desired delivery, or in selecting too low a coefficient of friction in the calculation, would result in a restricted supply and consequently a serious handicap to the operation of the plant.

The power house, Fig. 4, is on the north bank of the creek. It is of brick, 25 × 50 ft., and it is designed to accommodate two complete units of power development. Only one of these units has been installed, and this is at the east end of the building. That consists of a 400-HP. Cazin, twin 36-in. wheel, made by the American Impulse

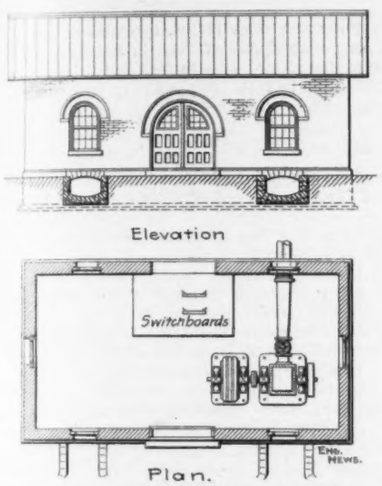


Fig. 4. Plan and Elevation of Power House, Utah Light & Power Co., Utah.

Wheel Co., direct connected to a 250-K-W., 3-phase, 60-cycle, 6,600-volt revolving field generator, made by the General Electric Co. The normal speed is 450 revolutions per minute. The Cazin wheel has two runners, each with 20 buckets and with two fixed nozzles with deflecting hoods. By the latter device, the force of the stream of water from a nozzle is regulated by a hood, which deflects part of it from its impact against the buckets of the wheel, as it is moved by the governor. A Lombard governor is used. The water used by the wheel drops into a tailrace and discharges into the creek.

At the west end of the building will be placed the second installation of power. The second steel pressure pipe will lead down to this. It is expected that 800 HP. can be generated when the second unit is installed. This cannot be done at all seasons, as during the later fall and winter the flow of the creek reduces to less than 25 sec. ft. At present about 300 HP. is used. No trouble has been had with the water freezing, and it seems that this is largely due to springs feeding into the creek a short distance above the diversion. The altitude of the latter is about 5,300 ft.

The current, at a voltage of 6,600, is transmitted to the town of American Fork over a pole line five miles long. Three No. 6 bare copper wires are used. The wires are attached to triple-petticoat, porcelain insulators, mounted on 30 ft. poles. At a substation at American Fork the voltage is reduced to 2,000, at which pressure it is transmitted to different points in American Fork, Lehi and Pleasant Grove. Each of the latter towns is 2½ miles from the former. At convenient places the voltage is reduced to 115, for incandescent lighting. For power purposes the voltage is reduced to 200.

At the end of one year's operation, in December, 1901, there were 4,000 incandescent lights in use. For power, there was a 20-HP. motor at a brickyard, a 50-HP. motor for running a flour mill, a 7-HP. and a 10-HP. motor used by the Utah Sugar Co., at Lehi (whose large plant is also lighted by the electric current), and many smaller motors, some of only ¼-HP. Inside of a year the plant was paying its operating expenses and interest on the cost of construction. Five men, all told, attend to the operation of the system, none of whom had previous experience in such work. The superintendent is Mr. J. H. Wooten.

The engineer who designed the system was Mr. R. F. Hayward, of Salt Lake City. Mr. Hayward is the chief electrical engineer of the Utah Light & Power Co., whose system is a combination of several large power plants near Salt Lake City and Ogden, and furnishes light and power for both these places. It should be said that Mr. Hayward's desire for the construction of a system first class in every respect was subordinated to a too strict economy of the owners of the Utah County plant, and, that while an excellent system has been built for the money invested, a much better pipe line would have been constructed if the engineer could have insisted on his own ideas being carried out. The total cost was about $60,000. The contractor for the work was Mr. Christian Garff.

NOTES ON LOST HEAD IN WATER SUPPLY SYSTEMS.

By A. Prescott Folwell, M. Am. Soc. C. E.*

In most branches of engineering, experiment must be the ultimate basis of all formulas, rather than theory alone; although theory is used to advantage in determining the general form of the formulas. Hydraulics is no exception to this; unfortunately certain theoretical hydraulic formulas have been used so universally as a basis for empirical ones that there is danger that many, especially of the younger engineers, may lose sight of the fact that the latter are not even theoretically correct, but are empirical in origin. Most of the empirical hydraulic formulas are modeled after the formula

$$v = \sqrt{2\,g\,H_v} \quad \left[\text{or, } H_v = \frac{v^2}{2\,g}\right],$$

which is theoretically correct. When, however, the assumption is made that friction head

$$H_f = \left\{f\,\frac{l}{d}\right\}\,\frac{v^2}{2\,g},$$

and that the head lost in a valve

$$H_g = c\,\frac{v^2}{2\,g},$$

it is made by empiricism, and as a matter of fact is given this form because of the convenience of having it similar to the theoretical

$$H_v = \frac{v^2}{2\,g}.$$

Thousands of experiments have been made to determine the values of f, c, and other coefficients in the empirical formulas, and these coefficients are found beyond shadow of doubt to be functions of v and d; that is, H_f, H_g and other losses do not vary as v^2, but as some other power of v. Mr. W. E. Foss showed in a paper in the "Journal of the Association of Engineering Societies" for June, 1894, that v varied practically as the $^{9}/_{11}$ power of d and H; or conversely, that H_f varies as the $^{11}/_{9}$ power of v. From experiments made by the writer during the past three years, he has derived exponents for v varying between 1.80 and 1.85; practically the same as Foss's $^{11}/_{9}$. In addition, what did not necessarily follow, he has found that the head lost in valves also varies as the $^{11}/_{9}$ value of v. Whether the head lost by other interference with the uniform flow varies as the same power of v there do not seem to be sufficient data to determine. In the case of straight pipes H_f seems to vary also inversely as $d^{4}/_{3}$ when the pipe is 12 ins. or more in diameter, and as $d^{7}/_{6}$ when the pipe is less than 12 ins. in diameter. If we consider H_f to vary as $v^{11}/_{9}$ and $d^{4}/_{3}$ or $d^{7}/_{6}$; then f must vary inversely as $v^{1}/_{9}$, and $d^{1}/_{3}$ or $d^{1}/_{6}$. From this, and using as a basis Merriman's table of coefficients for clean iron pipes, we find the formulas for flow in clean iron pipes to be very approximately

$$H_f = \frac{.028\ l}{d^{4}/_{3}} \cdot \frac{v^{11}/_{9}}{2\,g}, \qquad (A)$$

and

$$H_f = \frac{.028\ l}{d^{7}/_{6}} \cdot \frac{v^{11}/_{9}}{2\,g}, \qquad (B)$$

respectively, a constant coefficient of friction being used; these reducing to the forms

$$.000435\ \frac{l\ v^{11}/_{9}}{d^{7}/_{6}}, \qquad (C)$$

and

$$.000435\ \frac{l\ v^{11}/_{9}}{d^{4}/_{3}}. \qquad (D)$$

While these formulas are probably more nearly correct in form than the ones in common use, the calculation of the 1.83 (or $^{11}/_{9}$) and $^{7}/_{6}$ powers is less readily made than that of the square, even when logarithms are used, and it is probable that the forms

$$H_f = f\,\frac{l}{d} \cdot \frac{v^2}{2\,g} \quad \text{and} \quad H_g = c\,\frac{v^2}{2\,g}$$

will continue to be used. The use of these, however, with their variable coefficients, necessitates having at hand tables of such coefficients. Instead of placing such tables in his note book the writer carries with him for use away from the office the formula (C) for clean cast-iron pipes less than 12 ins. in diameter; and formula (D) for clean cast-iron pipes 12 ins. or more in diameter.

These can be used without logarithms, since

$$v^{11}/_{9} = \frac{v^2}{\sqrt{v^{1}/_{3}}};$$

$$d^{7}/_{6} = d \times d^{1}/_{6},$$

and

$$d^{4}/_{3} = d \times d^{1}/_{3}.$$

But it is convenient to have at hand a table of square and cube roots of numbers from 0.25 to 10 for use in this and many other ways.

The formula for velocity in pipes

$$v = \sqrt{\frac{2\,g\,h}{\frac{l}{d}}},$$

is likewise empirical, and requires variable values for f to make it accurate. In this case the accurate form becomes considerably more intricate, and it is more convenient to use the empirical. To meet this the writer uses the formulas

$$f = \frac{.028}{\sqrt[6]{v\,d^2}} \qquad (E)$$

for new iron pipe 12 ins. in diameter or over.

$$f = \frac{.028}{\sqrt[6]{v\,d}} \qquad (F)$$

for new iron pipe under 12 ins. in diameter.

$$f = \frac{.04}{\sqrt[6]{v\,d^2}} \qquad (G)$$

for all iron pipe 20 years or more old.

TABLE I.—Values of f for New Iron Pipe.

½ root.	Diam., ft.	Velocity in pipe, per second. 1′.	2′.	3′.	4′.	6′.	10′.	15′.
0.630	0.25	.0353	.031	.029	.028	.026	.024	.022
		.032	**.028**	**.026**	**.025**	**.024**	**.022**	**.021**
0.782	0.50	.0314	.028	.026	.025	.023	.021	.020
		.028	**.026**	**.025**	**.023**	**.022**	**.020**	**.019**
0.908	0.75	.0294	.026	.024	.023	.022	.020	.019
		.026	**.025**	**.024**	**.022**	**.021**	**.019**	**.018**
1.000	1.00	.0280	.025	.023	.022	.021	.019	.018
		.025	**.024**	**.023**	**.022**	**.020**	**.018**	**.017**
1.077	1.25	.0260	.023	.022	.021	.020	.018	.017
		.024	**.023**	**.022**	**.021**	**.019**	**.017**	**.016**
1.144	1.50	.0245	.022	.020	.019	.018	.017	.016
		.023	**.022**	**.021**	**.020**	**.018**	**.016**	**.015**
1.205	1.75	.0232	.021	.019	.018	.017	.016	.015
		.022	**.021**	**.020**	**.018**	**.017**	**.015**	**.014**
1.260	2.00	.0222	.020	.018	.017	.016	.015	.014
		.021	**.020**	**.019**	**.017**	**.016**	**.014**	**.013**
1.357	2.5	.0206	.018	.017	.016	.015	.014	.013
		.020	**.019**	**.018**	**.016**	**.015**	**.013**	**.012**
1.442	3.0	.0194	.017	.016	.015	.014	.013	.012
		.019	**.018**	**.016**	**.015**	**.014**	**.013**	**.012**
1.518	3.5	.0184	.016	.015	.015	.014	.012	...
		.018	**.017**	**.016**	**.014**	**.013**	**.012**	...
1.589	4.0	.0176	.016	.015	.014	.013	.012	...
		.017	**.016**	**.015**	**.013**	**.012**	**.011**	...
1.710	5.0	.0164	.015	.014	.013	.012	...	...
		.016	**.015**	**.014**	**.013**	**.012**	...	...
1.817	6.0	.0154	.014	.013	.012	.011	...	...
		.015	**.014**	**.013**	**.012**	**.011**	...	...
⅛ root.....		1.000	1.123	1.201	1.260	1.348	1.468	1.570

Note.—Figures in black-face type are from Merriman's "Hydraulics;" those in light-face were calculated by the author's formulas.

*Associate Professor of Municipal Engineering, Lafayette College, Easton, Pa.

TABLE II.—Losses of Head Due to Closing Valves.

Ratio: Diameter of full orifice to height of opening.	Values of d in the formula $H_d = d \frac{v^2}{2g}$; disk alone.					Values of c in formula $H_v = c \frac{v^2}{2g}$;		
	Weisbach 2½" valve and less.	Foiwell 4" valve, parallel face.	Foiwell 4" valve, wedge gate.	Kuichling 24" valve paral'l face.	Smith, 30" valve parallel face.	d in formula $H_d = d\,v^{11}/_6$; disk alone, 4" parallel face.	c in formula $H_v = c\,v^{11}/_6$; whole viv., 4" parallel face.	c in formula $H_v = c\,v^{11}/_6$; whole viv, 4" parallel face.
○	∞	∞	∞	∞	∞	∞	∞	∞
⅛	97.80	104.0	72.3	.....	86.6	1.49	104.16	1.493
¼	17.00	20.5	16.8	22.68	16.8	0.46	20.66	0.463
⅜	5.52	8.0	6.19	8.63	7.68	0.20	8.16	0.203
½	2.06	2.72	2.58	3.27	3.52	0.069	2.88	0.072
⅝	0.81	1.5	1.22	(1.00)*	1.50	0.033	1.66	0.036
¾	0.26	0.66	0.55	(0.25)	0.51	0.013	0.82	0.016
⅞	0.07	0.16	0.20	(0.019)	0.19	0.003	0.32	0.0060
1	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.0030

*Quantities in parenthesis were calculated by interpolation.

These formulas are deduced from those previously given for H_f. To show the accuracy of those for f (and those for H_f have exactly the same degree of accuracy), Table I. is given, comparing f as calculated by their use with the table of coefficients given by Merriman, compiled by him from the discussions of Fanning, Smith and others. As Merriman states, these are liable to an error of about one unit in the third decimal place. It is seen that for pipes 15 ins. in diameter or less the values by the formula exceed those given by Merriman, in some cases by 10%. As these, however, are the sizes most seriously and earliest affected by tuberculation and organic matter the difference is on the safe side, and, in the writer's opinion, by no means too much so.

The third formula (G) is based upon Coffin's tables and investigations (see "The Graphical Solution of Hydraulic Problems," pp. 24 and 66), and is applicable where allowance is to be made for tuberculation and growth of organic matter upon the inside of the pipe.

As an illustration of what error may occur in calculating the flow in clean pipe from an error of 0.001 in the value of f an illustration is given. Let h = 100 ft.; l = 10,000; d = 12 ins. Formula,

$$v = \sqrt{\frac{2\,g\,h}{f\,\frac{l}{d}}}.$$

If f be taken as 0.020, v is found to be 5.67 ft. per sec. If f be taken as 0.021, v is found to be 5.54; a difference of 2.3%. The results from either table or formula for f ordinarily should be correct within 3 to 5%. But it is so almost impossible to predict to what extent the inside of the pipe will change in rugosity that even using the best judgment in selecting f accuracy closer than 5% or 10% can hardly be expected in large pipes, nor closer than 15% to 50% in small ones. Where greater accuracy is desired, a special investigation should be made of values obtained in the case of pipes similar in size and in condition of inner surface.

In many calculations it is desirable to take into consideration the losses due to bends, valves and special castings. These are generally small in individual cases, but may reach a considerable total in an extensive system of pipes. Of loss due to valves there has been almost if not absolutely no data. Weisbach's experiments and formula are generally quoted in this connection, but this formula is not for the loss due to the valve as a whole, but only to the partial closing of the same, the loss for an open valve being called 0. His formula is: Lost head,

$$H_v = n \frac{v^2}{2g},$$

in which n has the values given in Table No. 2. These were from experiments made on small (½ to 2-in.) gate-valves. Later experiments have been made by Kuichling and Smith on 24-in. and 30-in. valves, respectively, but in these also the loss is given as 0 for an open valve. The writer has recently experimented on the loss occasioned by introducing a valve into a line of pipe, using more delicate apparatus for measuring lost head than had previously been used for this purpose. So far these experiments have been upon 4-in. valves, only; they show for such a valve a loss of

$$H_g = 0.16 \frac{v^2}{2g}, \qquad (H)$$

or, more accurately, $0.0030\ v^{1.9}$, in which v is the velocity in the pipe. This is about the loss in 5 ft. of straight pipe. As the velocity in a water pipe seldom exceeds 10 ft. per sec., this would mean a maximum loss of about 0.25-ft. for each open 4-in. valve. The law of relation between lost head and size of valve is not known, but probably H_g varies about inversely as d, so that for a 10-in. valve the maximum loss would be about 0.1-ft.

In Table II. are given also the losses due to partially closing valves, the results of the experiments above mentioned. An inspection of the table shows that the loss in head from partly closing a valve does not become very considerable until the valve is more than half closed. A practical application of this can be made in the case of large valves. In these, to avoid water hammer, which would be a serious matter in most cases, the closing mechanism is ordinarily so made that a considerable time must be occupied in closing the gate. This time could be cut in two with perfect safety by so arranging the mechanism that the first half or even two-thirds of the closing would be made rapidly, and the last part much more slowly. Or the valve could always be left half open with a probable loss in feet head at maximum velocity of not more than $\frac{3.3}{d}$, d being the diameter in feet. The same object can be attained by substituting a valve of but one-half to one-third the size of the pipe, a flat-angle reducer being placed on each side of the valve. This will, in most cases, effect a saving in cost, and likewise cause less loss of head than leaving the valve half closed.

The loss due to curves has generally been considered to be represented by the formula of Weisbach; Lost head,

$$= \frac{\text{Angle of deviation}}{180°} \left\{ 0.131 + 1.847 \left(\frac{d}{2R} \right)^{7/2} \right\} \frac{v^2}{2g},$$

the portion in brace being equal to from 0.13 to 2.00. This is seen to vary almost inversely as the 7/2 power of the radius of curvature. Recent experiments have seemed to show that the length of the curved pipe is an important factor of the lost head, and that the excess of lost head per foot of curve decreases as the radius becomes greater than about 2½ diameters. (See "Transactions

TABLE IV.—Velocity of Flow in Pipes in Feet per Second.

Gallons per day.	Size of pipe. 4-in.	6-in.	8-in.	10-in.	12-in.	14-in.	16-in.	18-in.	20-in.	22-in.	24-in.
10.	0.00018	0.00008	0.000044	0.000028	....	....	....	....	....	....	....
100.	.0018	.0008	.00044	.00028	....	....	....	....	....	....	....
1,000.	.018	.0079	.0044	.0028	0.0020	0.0014	0.0011	0.0009	0.0007	0.0006	0.0005
10,000.	.177	.079	.044	.0284	.0197	.0145	.0111	.0088	.0071	.0059	.0049
100,000.	1.77	.79	.443	.2837	.197	.145	.1108	.0876	.0709	.0586	.0492
1,000,000.	17.73	7.88	4.43	2.837	1.97	1.447	1.108	.876	.709	.586	.492
2,000,000.	....	15.76	8.86	5.674	3.94	2.894	2.216	1.752	1.418	1.172	.984
3,000,000.	....	23.64	13.29	8.511	5.91	4.341	3.324	2.628	2.127	1.758	1.476
4,000,000.	....	....	17.72	11.348	7.88	5.788	4.432	3.504	2.836	2.344	1.968
5,000,000.	....	....	22.15	14.18	9.85	7.235	5.540	4.380	3.545	2.930	2.460
10,000,000.	....	....	....	....	19.70	14.47	11.08	8.76	7.09	5.86	4.92
50,000,000.	....	....	....	....	....	....	....	....	....	....	24.6

TABLE III.—Areas of Pipe Sections.

Diam., ins.	Area, sq. ft.	Diam., ins.	Area, sq. ft.	Diam., ins.	Area, sq. ft.
4	0.08727	12	0.78540	20	2.18166
6	0.19635	14	1.06901	22	2.65281
8	0.34907	16	1.39626	24	3.14159
10	0.54541	18	1.76715	30	3.68700

American Society of Civil Engineers for May, 1901.) Then the formula

$$h_c = \frac{4.54\ h_t}{\sqrt[4]{\frac{R}{d}}}$$

(in which h_c is the lost head per foot of curve, and h_t the lost head per foot of tangent of same size and in which the velocity is the same) represents fairly well the result of these experiments. From the same experiments the writer has derived the formula

$$H_c = \frac{.003\ v^{11/6} \left[\frac{R}{d} \right]^{3/4}}{\sqrt[6]{d}} \qquad (I)$$

for pipes 12 ins. or more in diameter, and

$$H_c = \frac{.003\ v^{11/6} \left[\frac{R}{d} \right]^{3/4}}{\sqrt[6]{d}} \qquad (J)$$

for pipes less than 12 ins. in diameter, in which H_c is the total loss of head in a 90° curve, R is the radius of the curve in feet, and d the diameter of the pipe in feet. For ordinary cast-iron bends this becomes practically

$$.005 \frac{v^2}{\sqrt[6]{d}},$$

or about the loss in 10 ft. of tangent.

Of the loss of head occasioned by special castings, no measurements of any value are known of by the writer; but he assumes that a tee causes half as much and a cross twice as much loss as a valve—an assumption based upon a rather arbitrary application of laws of flow to the comparison of specials and valves.

As a conclusion from the above discussion the writer recommends as being sufficiently accurate for most purposes the approximations:

Loss in open valve (above that in an equal length of straight pipe) = that in 5 ft. of straight pipe.

Loss in half-closed valve = that in 80 ft. of straight pipe.

Loss in ordinary cast-iron 90° bend = that in 10 ft. of straight pipe.

Loss in ordinary tee = that in 3 ft. of straight pipe.

Loss in ordinary cross = that in 10 ft. of straight pipe.

And formulas E, F and G.

In calculating the lost head in any line of pipe, where account is to be taken of the effect of valves and bends, the length of pipe may be considered increased by the above amounts and the calculation made as for straight pipe. It is believed that none of these formulas will give a result differing by more than 3 to 5% from that obtained by using general tables based upon the most reliable and recent experiments; and the uncertainties existing as to the condition of the inner surface of the pipe, actual flow to be provided for, etc., render this ordinarily as close an approximation as is called for. If, however, the line is a very important and large one, neither formulas nor tables should be relied upon, but special investigations made by trained hydraulicians.

Tables Nos. III. and IV. will be found convenient in making calculations in pipe hydraulics.

DEFECTIVE BRIDGE CONSTRUCTION IN THE PRAIRIE STATES.

By Daniel B. Luten.*

A type of steel bridge which has of late years become very popular with certain county commissioners and engineers in the Central and Western States is the so-called leg bridge, illustrated in Fig. 1. For short spans, it consists of steel girders, usually I-beams, spanning the opening and supported at each end by uprights or legs of steel I-beams with riveted or bolted connections to the girders and resting upon timber mud-

*Lafayette, Indiana.

sills embedded three or four feet beneath the bed of the stream. A backing of wooden plank, sheet steel, or flagstone, rests against these legs, and supports the earth filling of the roadway. Wing walls consist of vertical steel beams similar to the legs of the bridge, resting upon mud-sills and riveted to an angle across their upper ends, with a backing to support the earth of the embankment similar to that in front. To prevent overturning from the earth pressures, the wings are supported by steel tie rods, joining wing to wing, under the surface of the roadway. A system of lateral bracing joining the legs, prevents the bridge from collapsing sideways. Knee-braces are sometimes provided, from the girders to the up-

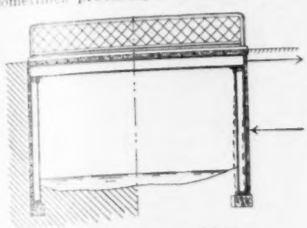


Fig. 1. The "Leg" Bridge.

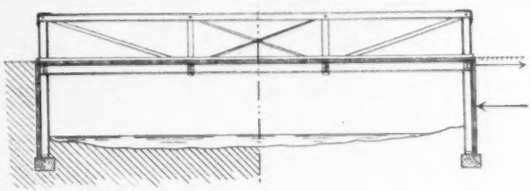


Fig. 3. The "Bedstead Truss" Bridge.

rights, where the area of waterway will permit of their use.

For locations subject to considerable floods, the legs are sunk to a greater depth in the bed of the stream, or else the mud-sill may be omitted and the steel uprights driven as piling to a depth of eight or ten feet. A bridge of this latter type with driven legs, and with flag stone backing, is shown in Fig. 2.

The floor is usually of wood, since the more permanent floors would prove too heavy a load for the mud-sill and leg supports.

A modification of the leg bridge which is used for spans of from 30 to 60 ft. is the bedstead truss shown in Fig. 3. It is preferably built with riveted connections, but is often pin-connected; the end post of the truss is extended downwards to form the leg support as in the leg bridge, and is securely riveted to the end of the upper chord member. The lower chord is usually made a compression piece in the two end panels only, since the pressure of the earth filling against the legs may be assumed to overcome the tension in those two members.

The principal argument for such bridges are their cheapness as compared with steel girder bridges on stone or concrete abutments, especially in the prairie states where material for such abutments is difficult to obtain. County commissioners and others not having competent engineering advice to guide them are led to believe, from the fact that steel is comparatively durable even when exposed, that a "leg" bridge will be a reasonably permanent improvement. Bridge companies under keen competition supply the cheap-

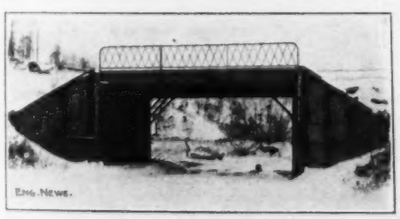


Fig. 2. Typical Leg Bridge, with Flagstone Backing.

est type of bridge that the commissioners will accept; for otherwise some other bridge firm would slip in with a cheaper type of structure and capture the contracts.

The leg bridge has two defects, one of which is apparent to all and is not usually considered as very serious, and another which is almost always overlooked by the ordinary purchaser, but which is much more serious than the first. The first is the liability of the steel surfaces of the legs to rust where embedded beneath the surface of the ground or submerged in the stream; for, of course, in such a location it is impossible to apply any kind of a protective coating after the structure is in place. Under such circumstances the steel legs might endure for twenty or thirty years without a dangerous reduction of the section through corrosion; and the popular opinion is that it will endure much longer, which is assumed to be sufficient for small structures. "Let the next generation care for its own bridges," is not an unusual argument.

The second and principal objection to this type of structure is that in most locations it is almost sure to be destroyed in a dozen years by the pressures of the earth filling combined with the expansion and contraction due to changes of temperature. The structure will grow weaker and weaker under these forces, but failure will be most apt to occur at times of high water or immediately after, when the earth filling is saturated and semi-fluid, exerting a maximum pressure against the legs. The destruction of the bridge is then charged to the high water, which it is urged, no one could have prevented!

In these leg bridges no provision whatever is made for expansion of the steel girders. They are riveted or bolted securely to the tops of the uprights. With increase of temperature, the expansion of the girders must be taken up by the yielding of the embankment, by the elasticity of the material of the girder, or else by shearing of the rivets or bolts. What happens is probably a combination of the two former, resulting finally in shearing of the rivets and destruction of the bridge. When the bridge is first erected the earth filling is of course compacted against the backing of the legs. With decrease of temperature, the girders shorten appreciably, drawing the tops of the legs inward and the earth backing will of course follow, settling against the legs in their new position. With rise of temperature, the expanding girder must press back the tops of the legs, resulting either in crowding the mud-sills and lower ends of the legs into the stream or else in slightly bending the legs. The process is repeated with recurring changes of temperature, the earth embankment continually encroaching on the span and each time getting a better hold, so to speak, until finally the connections at the top give way. The dotted lines on the right of Fig. 1, give an exaggerated idea of the resulting shape of the legs under this action. The legs toe-in and become knock-kneed!

Assuming a leg bridge of 20 ft. span, and range of temperature of 100° F., the change in length of the span, for a coefficient of expansion of 0.000,0065 for steel for 1° F., would be ⅛-in. If the earth embankment were to be considered as absolutely secure, and not yielding in the least to the expansion, the change in length would be taken up by the girder. Assuming the coefficient of elasticity of steel as 28,000,000 lbs. per sq. in., the resulting compression would be 18,200 lbs. per sq. in. Of course the embankment does yield, at least near the top, so that the above analysis is of interest only as the limiting case. It is of course impossible to analyze even approximately the resistance of the earth filling to the expansion of the girders, although it is apparent that it must be much greater than the actual pressure of such an embankment against a stationary wall. It is also evident that with increasing depth of water, which easily penetrates behind the backing, the earth filling must be softened and its pressure very much increased, while at the same time the resistance of the material of the bed of the stream to the tendency of the mud-sill and lower ends of the legs to give way under the pressure from behind is decreased by the scour and softening of the bed.

Of course it cannot be charged directly that failure to provide for expansion is responsible for the washing out of such bridges at times of high water. It can easily be shown, however, by records, that such bridges are nearly always the first to go, and in fact have almost no flood-resisting qualities whatever, although their foundations are usually placed far enough below the bed of the stream to avoid undermining. The wrecks of such bridges destroyed by floods, invariably show the legs torn from the girders, although this of course would be likely to happen in subsequent rough treatment, even if the bridge were washed out bodily. It may be noted, however, that such a bridge, securely held by the two embankments, can hardly be washed out except by collapse of the legs. It seems entirely impracticable to provide for expansion or contraction in these leg bridges, and the necessary conclusion is that such a type of structure is an inherently defective and unreliable form of construction.

A patented type of the leg bridge has been introduced to a limited extent, in which the legs are securely riveted across the end of the girder; in erection, the earth filling is tamped against the back of the legs so as to crowd the base towards the stream, producing an upward bending moment in the girder, which opposes the moments caused by the load. This type of bridge is computed as a girder with fixed ends, but of course there can be no assurance that the forces developed can even be approximately equal to their assumed values.

The bedstead truss has not proved as popular as the leg bridge, due probably to the fact that for longer spans, the difference in cost of a truss on legs, and one on masonry abutments is not so pronounced. Of the leg bridges, upwards of 200 were erected in Indiana alone during 1901, while of the bedstead trusses about 40 were erected. In the bedstead truss the earth pressures against the legs reduce the tension in the lower chord, but of course increase the compression in the upper chord members. It is no unusual thing to find the entire lower chord of a four-panel bridge of this type in compression, and the entire floor system vibrating under the passage of a loaded wagon, without actually producing any tension in those members. The floor joists are usually arranged to take a portion of the thrust of the embankment, with a corresponding tendency to produce tension in the upper chord, in which case it is very similar to the leg bridge in providing no possible allowance for expansion. In any case the forces are indeterminate, and a satisfactory analysis of the truss is impossible.

In specifying wood backing for the legs of these types of leg bridges, commissioners perhaps unwittingly show wisdom, as it is doubtful if such structures will ordinarily endure for a much longer period than the timber backing.

Fig. 4. Leg Bridge, with Posts Forced Inward at Base.

Fig. 4 is a photograph of a steel leg-bridge with wood backing, which is five years old, and in which the span at the base of the legs is already four inches less than at the floor although the span was undoubtedly the same at both points when the bridge was first erected. In the bridge shown in Fig. 2, the stone backing has been broken in numerous places, evidently by the pressure of the legs, as most of the cracks are vertical and behind the uprights. The end of one broken stone on the left may be seen dislodged and nearly ready to fall away from the earth backing.

AN 8-IN HYDRAULIC GATE VALVE ON A DETROIT WATER MAIN SUPPLYING RIVER ROUGE, MICH.

By Geo. H. Fenkell, Jun. Am. Soc. C. E.*

The water-works of the city of Detroit supplies water to several outside municipalities, among which is the village of River Rouge. This particular supply is by means of an 8-in. main, in which is set an 8-in. automatic hydraulic gate. The gate ordinarily remains closed, the water passing

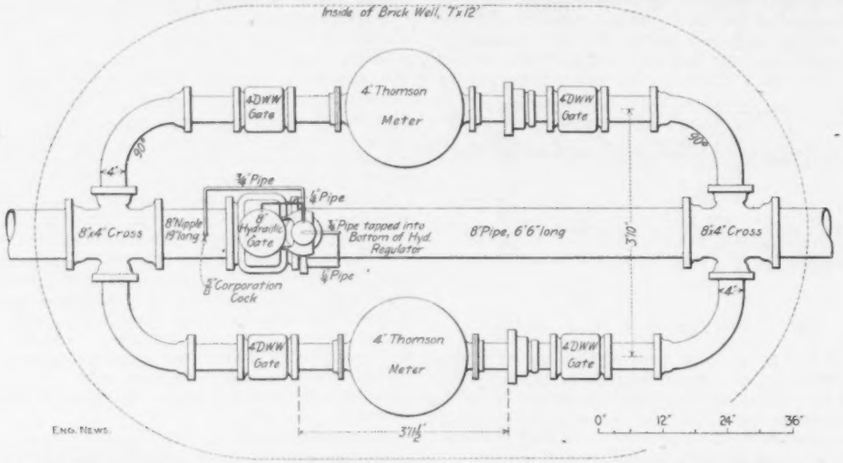


FIG. 1. GENERAL PLAN OF 8-IN. AUTOMATIC HYDRAULIC GATE ON THE DETROIT WATER MAIN SUPPLYING RIVER ROUGE, MICH.

through two 4-in. Thompson meters, Fig. 1, set on by-passes around the gate. The weighted valve, which admits water to the hydraulic cylinder controlling the gate (see Figs. 2 and 3), depends for its action upon the difference in pressure between the up-stream and down-stream sides of the gate, and is entirely independent of the absolute pressure.

By adjusting the weights this valve can be regulated to operate at any point desired. In this case it is set to operate when the resistance through the meter reaches 5 lbs.

When the demand for water is suddenly increased beyond the capacity of the meters, as in case of fire, or for any other reason, the gate begins to open as soon as the resistance through the meters reaches 5 lbs., thus preventing the possibility of a short supply at a critical time.

If the greatly increased consumption occurs when but ordinary pressure exists on the pipes, the gate only opens enough to maintain a constant difference of pressure on either side. This condition might be occasioned by a broken main; in which case, although the gate would pass some unmetered water, it would prevent breakage in meters due to very high velocities or stoppage of meters by any foreign substance.

In case of a fire, the pressure, which is ordinarily 25 lbs., is raised to 70 lbs., which is sufficient to operate the small catch against its spring, Fig. 3, and thus hold the valve in such a manner that the gate will open wide, regardless of the quantity of water consumed, and remain open as long as the fire pressure is on. When the pressure drops to normal, this spring catch is released and the gate closes down as before.

The piston in the hydraulic cylinder to the gate receives pressure to operate it on but one side at a time, the other side discharging into the air. In case of fire, nearly all the water used passes through the gate and is not metered, but can be determined by a counter on the fire pump, similar to those used on hydraulic elevators.

The valve and hydraulic cylinder of this gate are fitted to the regular Detroit water-works standard solid wedge gate.

This device has now been in operation since September, 1900, and has been examined from time to time and found working well. The valve and hydraulic piston have given perfect satisfaction, and work as easily to-day as when set. The only trouble experienced has not been of a serious nature, but was found where least expected; in the disk of the gate itself, which is, as before stated, of the solid wedge type, the bevel on each side being 13-16-in. to 1 ft. It is found that when this disk remains closed for some time it sticks slightly in its seat, though not to a serious extent. All other sizes of Detroit water-works standard gates have a bevel on each face of 1 in. to 1 ft., and, so far as known, have never given trouble by sticking in this manner.

The ports admitting water to the hydraulic cylinder are made purposely small in order that the gate may move slowly and not "flutter."

The automatic gate was designed by the writer and inspected during construction by A. F. Dierkes, Mechanical Draftsman, all under the direction of Clarence W. Hubbell, Assoc. M. Am. Soc. C. E., Civil Engineer to the Board of Water Commissioners of the city of Detroit.

*Chief Draftsman Detroit Water Board.

SOME NEEDED REFORMS IN THE CONDUCT OF RIVER AND HARBOR WORK.

At the National Rivers and Harbors Congress, held at Baltimore in October last, an address was delivered by Hon. Theo. E. Burton, of Ohio, Chairman of the Committee on Rivers and Harbors of the House of Representatives. In the course of this address Mr. Burton set forth some of the evils attendant upon the present method of providing for and carrying on river and harbor works. We have never seen anywhere such a clear, fair and forcible presentation of this important subject, and we take space therefore to reprint this portion of Mr. Burton's remarks in full, as follows:

While favoring appropriations for rivers and harbors, it is not well for us to be blind to the errors and dangers incident to legislation of this kind. So I count it appropriate to suggest on this occasion certain reforms and questions for discussion. These suggestions must be understood as made upon my own responsibility, rather as a citizen or a student of the subject, than as a legislator. It is true the responsibility for action rests with Congress, but outside opinions are valuable, and the influence of such a gathering as this can be most salutary in promoting better administration and the enactment of more perfect laws. At any rate, much will be gained by full and free discussion.

(1) There should be a rigid exclusion of all extraneous subjects from River and Harbor Acts. They should be restricted to items which immediately benefit navigation. There have been serious violations of this rule. Of late years strong pressure has been brought to bear to include in the River and Harbor Bill appropriations for reservoirs to be constructed for the purpose of irrigating lands. It is certainly incongruous to include in a bill which has to do with navigation provisions for reservoirs 7,000 ft. above the level of the sea in localities hundreds of miles from navigable water, and where the natives have never seen any style of boat except a birch-bark canoe. Twice it has been necessary to take the radical stand that if these projects must be included in the bill the whole bill must fail. The problem of the reclamation of arid lands is an important one, but whatever is determined by Congress should be by a bill which has to do with irrigation alone. It should be a measure recommended by a committee chosen for the consideration of this subject, and not one tacked on to [illegible] other bill, relating to entirely different matters.

Another form of questionable appropr[illegible] often included in river and harbor bills is the pr[illegible]on for protection or rectification of the banks of [illegible]al streams. Very large sums have been included for t[illegible]rpose, and mostly in localities in which there is [illegible]navigation. Should the general government underta[illegible]c task of protecting the banks of rivers where th[illegible]nels shift or wash away the adjacent land, the ex[illegible]ure would in time come to equal the amounts now ex[illegible]d for navigation. In the last Congress a member [illegible]red before the committee who advocated an appro[illegible]n for the rectification of the banks of a river at a [illegible] in his district. It was pointed out that the total [illegible]se of the project which he advocated would be over [illegible]00, while the population of the town, by the last [illegible] was only 3,319, so that there would be an expenditure of over $200 for each inhabitant—that, too, in a locality where, for a stretch of 1,000 miles upon the river, the total tonnage carried barely exceeded one cargo for an ocean ship of the largest size. Another point which has arisen in this connection has been the expenditure of money for the protection of embankments upon which highways and railways are located and for the support of piers of bridges. Such

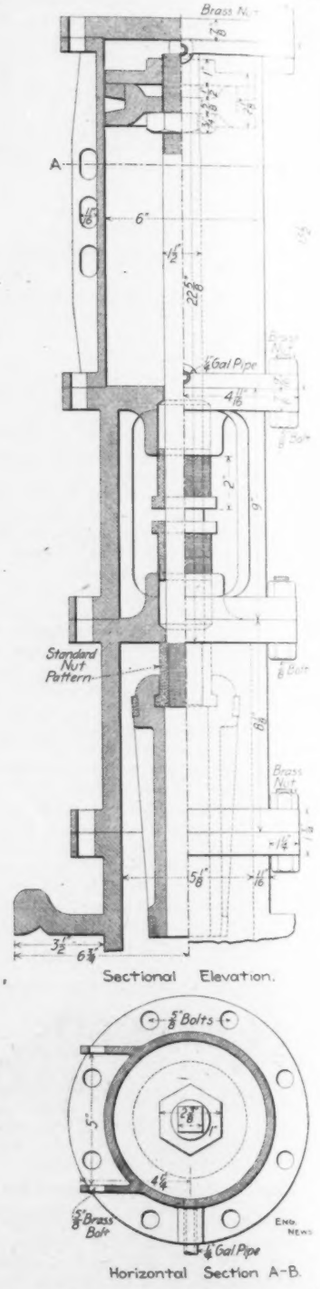


Fig. 2. Details of 8-in. Hydraulic Gate for River Rouge, Mich.

expenditures clearly do not belong to the River and Harbor Bill, and, incidentally, it may be said that appropriations made for these purposes have been so made as to benefit railways and other corporations, which should themselves bear the burden.

(2) More careful comparison of reports made by the government engineers, with a view to securing uniformity in their recommendations. Under the present system each of the different engineer officers reports upon the advisability of an improvement which he is called upon by Congress to investigate. If he has the rank of colonel or lieutenant-colonel his reports go immediately to the chief of engineers and are by him transmitted to Congress; if his rank is below lieutenant-colonel they go to the division engineer, who approves, rejects or modifies it. As a result this nature, but it would certainly secure uniformity, and eliminates many objectionable projects if such a board could be constituted. It is a matter of common experience that frequently the most extravagant projects are most strongly pressed upon Congress, and are supported by the most specious arguments. If once a proposed improvement has a favorable recommendation from an engineer it is difficult to prevent its adoption.

(3) A more uniform rule in drawing the line between work which should be done by the government and that which should be done by private parties or municipalities.

An examination of past appropriations shows an absolute lack of uniformity. In the harbors upon the Great Lakes, most of which are made up of small streams emptying into the lakes, in some instances the government has

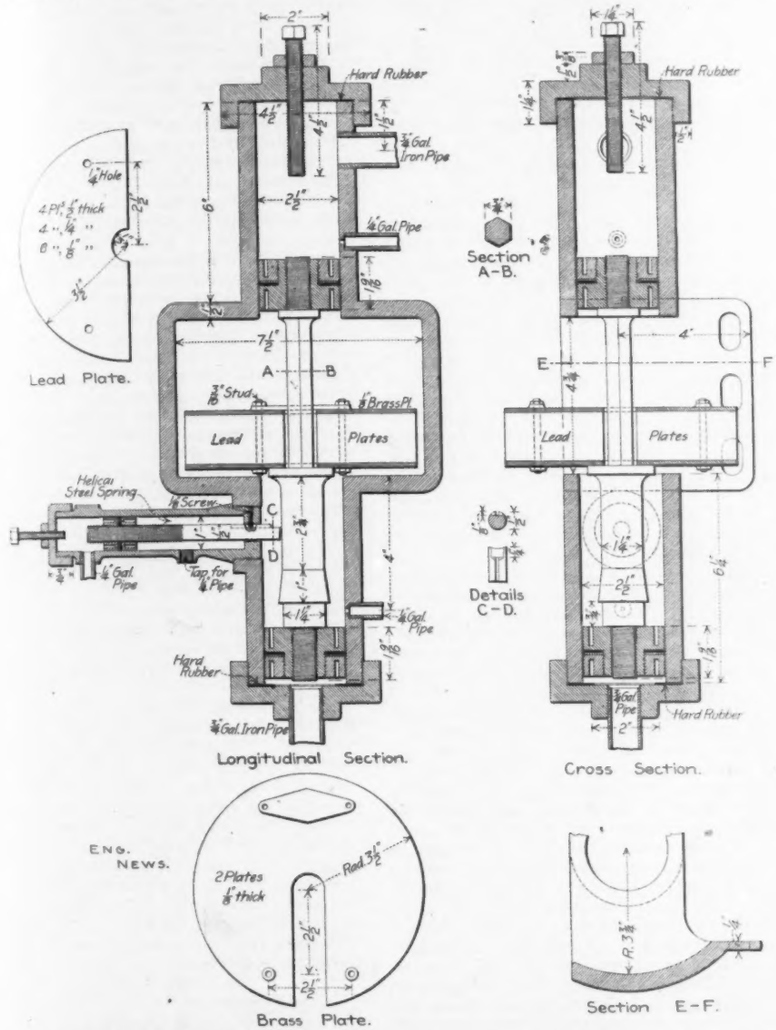


FIG. 3. DETAILS OF AUTOMATIC REGULATOR FOR 8-IN. HYDRAULIC GATE, RIVER ROUGE, MICH.

reports are made according to the different degrees of conservatism or liberality of the different officers. To illustrate, an improvement is submitted to an engineer for investigation which involves a probable annual commerce of $500,000 and which will cost $200,000. The engineer, considering this, having liberal ideas as to the expenditure of public money, or possibly influenced unconsciously by local partiality, will report upon the project as one which should be undertaken by the national government. In another case, a proposed improvement promising twice as much commerce will be investigated where the expense will be only $100,000, or half as much as in the first case. The engineer examining it, being of a more conservative type, will report adversely. These reports alike go to Congress. A section was included in the bill which failed last winter which would obviate this difficulty. Under its provisions a board of seven engineer officers was to be constituted, to whom were to be submitted all reports made by engineers, with the intention that they should report upon each according to its merits and follow a uniform standard. Improvements recommended by the Light-House Board are divided into three classes, which are styled, respectively, "Indispensable," "Necessary" and "Desirable." It may not be best to make a division of ceased its work at the mouth of the stream, while in other localities it has done the dredging up the stream in front of private wharves and docks. One rule is followed at Buffalo, another at Chicago. In the improvement of rivers at cities located at the head of navigation the improvement in some cases has ceased at the lower, and in others at the upper limit of the municipality. In many localities this last question is one of very considerable importance, because of the cost of removing rock or quarrying private property at a very considerable price.

(4) The combination of appropriations for numerous small projects.

An examination of river and harbor legislation will show an unusual number of projects in each bill. In that which failed last winter 401 improvements were provided for. Each of these would require a separate contract, and some of them, as in those in which there is provision for locks and dams, would require more than one. Would it not be well to group together in one appropriation and one contract a number of small projects where there are appropriations of, say, from $1,000 to $20,000, or even much more, so that expense of the location of the plant may be shared by all of them? I can select no better illustration than that afforded by four harbors in this State on the easterly side of the Chesapeake Bay, namely, Cambridge, Rock Hall, Claiborne and Queenstown. Suppose for each of these a sum approximating $5,000 is appropriated. For each a plant is separately located, and much of the amount available is exhausted for this purpose. The objection to this, of course, is the local pride of each community and the settled custom of separate appropriations which has prevailed for many years. But a great amount of work could be secured by consolidating such projects, fixing the proportion that each should receive, or leaving that to the discretion of the engineering department.

(5) It is clear that appropriations should not be made merely in order that money may be expended in any locality. Work is only valuable provided adequate results follow. Nor should appropriations be made to improve channels where the sole benefit will accrue to private parties or to a small number of owners. If there is a bay around which there is but one ownership it is not the duty of the general government to improve the entrance to that bay.

Another question is worthy of discussion. Could a system be devised under which a part of the expense of river and harbor improvements, or of some classes of improvements, shall be borne by the adjacent municipalities, similar to those in force in cities in making special improvements, in which part is assessed upon the general fund and part upon the neighboring property? This division of expenses has found many advocates, and much can be said in its favor from the standpoint of principle. On the other hand, such a division is beset with difficulties. In stating the objections to this plan, I cannot do better than to repeat some remarks made in a discussion of the River and Harbor Bill on the 6th of April, 1896:

> It is true that plausible arguments have been made for the adoption of a system in this country under which a fraction—say, one-third or one-fourth—of the expenses of our river and harbor improvements should be paid by local authorities or collected from the locality regarded as especially benefited and the balance by the general government. It is maintained by the advocates of this plan that this division would secure a more equitable adjustment of the burden of the expense and assure good faith and the exercise of the best judgment in the adoption of projects for improvement.
>
> The objections are that all these projects have come to be regarded as distinctly national in their character, and not to be undertaken unless proper subjects of expenditure from the national treasury; that the necessity of including different localities and States in a single improvement would require a concert of action by numerous, and perhaps varying, interests almost impossible to obtain; and further, that less deserving projects would be presented with offers to furnish the portion to be paid by local taxation, which would obtain recognition to the exclusion of more valuable projects for which less pecuniary support could be furnished.
>
> On the other hand, it is argued that such a division would result in no improvements being undertaken unless they had the financial support of the localities immediately affected. There are certain improvements no proportion of the expense of which could be well apportioned to private parties, to municipalities or to States. If there is a river which passes through several States it would be difficult to divide the expense or obtain equal support from each of the localities benefited, but there are improvements where it must be admitted that an exceptional benefit is conferred upon a locality distinct from that which is gained by the public at large. In such a case the improvements should be either rejected entirely or a part of the expense imposed upon the property immediately benefited.

A perplexing question arises upon the proper course to be pursued in improving river channels which compete with railway systems. On the one side we have the admitted fact that points which have river navigation are granted lower railway rates. To an extent the regulation and decreasing of railway freight rates is a valid argument for the improvement of channels, but this question should be determined on broad lines and in accordance with well-settled principles pertaining to transportation. Generally speaking, railway transportation occupies one field and water transportation another. Water transportation is to be preferred for heavy freight, for those which need not be transmitted promptly and for articles of smaller value per ton or which do not require careful housing. On the other hand, railway transportation is available at all seasons of the year, and is presumably more prompt, and can afford greater care in the handling of freight; it also, by connecting with other lines, at least for domestic trades, makes shipments for longer distances possible. In advanced industrial locations, where both water and railway routes are available, the adjustment of the selection of the method for carrying freight is accomplished without friction, and each means of communication increases the business of the other. The objection to the river or canal improvements is greatest when two points are located upon a river between which there is a railway, and the river has to be supplied with unreasonably expensive locks and dams or other improvements. To improve such a river, in order to create competition, is like building a road over uneven surfaces and by a roundabout way instead of going by a straight and level course. In such a case the securing of reasonable railway rates should be accomplished by proper legislation, either by the State or National Government, rather than by the expen-

sive process of building elaborate canals or improving rivers, because the difficulties are such as to make railway transportation the natural and rational method for carrying freight.

SUGGESTION FOR A MORE UNIFORM PRACTICE IN FIXING THE LENGTHS OF SPIRAL CURVES.

By W. D. Taylor,* M. Am. Soc. C. E.

Though much has been said of late years on the subject of spiral curves, the writer thinks that possibly the subject will bear some further treatment.

Another engineer has recently called the attention of the writer to the suggestion that on every railroad the four quantities, viz.: (1) The degree of curve, (2) the amount of superelevation, (3) the speed of the prevailing fast trains, and (4) the length of the easement curve, might be with some economy connected by some uniform rule.

The folly of adhering strictly to a uniform rule for the superelevation of all curves, such as 1 in. per degree of curve—whereby a 6° curve at the top of a grade near a station where all trains run slowly, is given the same superelevation as the same degree curve at the foot of two long grades where the trains pass at high velocity—has often been pointed out. So that now on roads where good engineering practice prevails, we will find the rate of superelevation different, as it should be, in the case of two such curves.

But since the use of the spiral or easement curve is a matter of comparatively recent practice, and is even now far from being general, the principle of making an economical adjustment of the length of spiral used to the degree of curve, the amount of superelevation, and the velocity used, has possibly not been quite so well expounded. But on many roads the rule fixed upon by which to spiral the curves on old track would make the length of spiral, or rate of transition, the same for the 6° curve at the top of the grade as for the one at the foot of the grade. The originator of the true spiral curve himself (see E. Holbrook, in Engineering News, June 13, 1901), says:

> 20 years' experience has demonstrated that a single rate of transition should be used on new work, and it is very rare that more than two are required on old work. If we use two rates, viz., 1° in 30 ft., and 1° in 60 ft., we can relocate curves up to 6° without getting the stakes outside the rails.

On the Tampico Branch of the Mexican Central 20 years ago, under the instructions for locating engineers, the same rate of spiraling was required for all curves. The chain was 25 meters, and the rate of transition was 1 degree in 12.5 meters, so that in spiraling a 4° curve the spiral was 37.5 meters, or 123 ft., long, and the curve was offsetted from the tangents about a foot; while the spiral for a 12° curve—and there were many such—was 137.5 meters, or 452 ft. long, and the curve was offsetted some 24 ft. from the tangents. While it is not claimed that any one in spiraling curves on old track would go to such an extreme as this, the example illustrates that Mr. Holbrook's rule is rather broad.

In figuring the cost of spiraling curves on old track the authors of treatises and papers on this subject seem to pay most attention to the cost of the engineering work of staking out the curves rather than to the amount of track shifting, regrading, and reballasting, necessary to get in the spirals. This last is really the costly part of the work, and it will be found in every case that the total cost of spiraling a curve varies almost in exact ratio with the amount of track shifting necessary to put in the spirals. To properly and economically adjust the two curves mentioned above to the needs of the traffic, it is certainly necessary to use a higher rate of transition or shorter chord lengths on the curve at the top of the grade.

Since the cost of spiraling a curve varies nearly with the amount of shift in the track, and the amount of shift varies as the square of the chord length of spiral used, it is plain that, pre-supposing equal central angles, if a 30-ft. spiral will make the same satisfactory adjustment to the traffic of the curve at the top of the grade as a 60-ft. spiral of the curve at the foot of the grade, we can spiral the former at about 25% of the cost of spiraling the latter.

So far as the writer knows, no engineer has attempted what might be called a scientific adjustment of the four quantities mentioned above. Mr. C. A. Morse, M. Am. Soc. C. E., Principal Assistant Engineer of the A. T. & S. Fe. Ry., who first brought this subject to the writer's attention, has calculated spiral tables for use on his road for velocities between 30 and 60 miles per hour, inclusive.* Several writers seem to have such an adjustment in mind, as: C. A. Sundstrom, in "Trans. Am. Soc. C. E.," Vol. 46, p. 385; Prof. J. C. Nagle, in his "Manual for Railroad Engineers;" Prof. Talbot, in his "Railway Transition Spiral;" and F. K. Vial, in Engineering News, Sept. 20, 1900. In this article Mr. Vial says: "The rules to determine the length of spiral are often very crude," and then proceeds to show that the rate of transition should vary inversely as the cube of the velocity.

In the report of W. M. Camp to the American Engineering and Maintenance-of-Way Association, in March, 1901, on "Curve Elevation," he cites replies from 58 practical Maintenance-of-Way men in answer to the question: "At what limit of curvature do you think speed of 60 miles an hour should not be exceeded?" The weight of the opinions given favors a limit of curvature for this speed slightly in excess of 4°, and 21 of the 58 replies specifically name 4° as this limit. As to the maximum superelevation allowable, 41 replies give the weight of opinion in favor of 6¼ ins. The same report shows that the most usual rate of running out superelevation is 1 in. in 60 ft.

The velocity in miles per hour at which the centrifugal force is just (approximately) balanced by an elevation of 6¼ ins. on curves of different degree is given in the second column of Table I. herewith. But the consensus of opinion agrees that 60 miles an hour is a safe velocity on a 4° curve; and the centrifugal force on a 4° curve at 60 miles an hour is 58% more than at 48 miles an hour, which latter is the velocity at which the centrifugal force is just balanced by the centripetal force of 6¼ ins. of superelevation on a 4° curve.

At 60 miles an hour on a 4° curve with 6¼ ins. of superelevation, there is an amount of the centrifugal force unbalanced by the superelevation of the curve equal to 6.2% of the weight of the car body. If it is safe, then, to run 60 miles an hour on a 4° curve with 6¼ ins. of superelevation, it is equally as safe, at least so far as centrifugal force is concerned, to run 120 miles an hour instead of 95.5, on a 1° curve, or to run 35 miles an hour instead of 27.5 on a 12° curve, both curves having 6¼ ins. superelevation. For the centrifugal force in each case mentioned is roughly 6.2% of the weight in excess of that balanced by the superelevation. The third column of Table I. gives, estimated on this basis, the safe maximum velocities on curves of various degree elevated 6¼ ins.

If a grade of 1 in. in 60 ft. be found satisfactory for the outer rail to run up from a level to 6¼ ins. of superelevation for the speed of 60 miles an hour on a 4° curve, the length of spiral for this velocity and curve would be 375 ft. or, in the usual nomenclature, a 94-ft. spiral would be required. A train at 60 miles an hour would run over the length of this spiral in 4¼ seconds. If it is found that the "curve shock" to passengers and rolling stock is removed by giving the train or car body 4¼ seconds at this velocity, and on this curve, to climb the superelevation grade and adjust itself to the curve elevation, the writer suggests that the most economical lengths of other spirals to be used on other curves with different velocities can best be determined by the proportional amount of *time* it takes the car body to run up the superelevation grade. For the sole object of a spiral is to ease off the *suddenness* of the change of direction.

The fourth column in Table I. gives for various degrees of curve and the various estimated safe maximum velocities on those curves, the total length of spiral, or, what is the same thing, the length of grade to run up to 6¼ ins. of superelevation, calculated from the requirement that the car body shall have, at the maximum allowable velocity on the curve, 4¼ seconds to pass over the spiral. The last column gives the resulting "foot spiral."

Tables II. and III. give the same quantities when the superelevation is 4 and 2 ins., respectively, the estimated safe maximum velocity in each case being that at which the centrifugal force is 6.2% of the weight of the car body in excess of the amount balanced by the superelevation. The length of spiral is determined from the amount of *time* it takes the car at the maximum allowable velocity to run up the superelevation grade height of 4 ins. and 2 ins., respectively. The connection between the tables is that the ratio of the time of a car body on the spiral at the maximum velocity to the amount of the superelevation is constant.

$$\text{That is, } \frac{4.25}{6.25} = \frac{2.72}{4} = \frac{1.36}{2}$$

The tables are only approximately accurate, being calculated throughout with slide rule.

*Professor of Railway Engineering, University of Wisconsin, 415 Wisconsin Ave., Madison, Wis.

*The writer would like to state that this article was written and sent to Engineering News before he had seen the paper by Mr. Morse in Engineering News of March 27.

TABLES PROPOSED FOR CONNECTING THE DEGREE OF CURVE, THE SUPERELEVATION, THE MAXIMUM VELOCITY AND LENGTHS OF SPIRAL.

Table I.—Superelevation 6¼ ins. Time to run over spiral at maximum allowable velocity 4.25 secs.

Degree of curve.	Velocity balanced by 6¼ ins. elevation, —miles per hour—	Estimated safe maximum velocity, —miles per hour—	Total lengths of spiral ft.	Feet per 1 degree increase of spiral.
1° 00'....	95.5	120	750	750
1° 30'....	78	98	612	407
2° 00'....	67.5	85	532	266
2° 30'....	60.5	76	475	190
3° 00'....	55.0	70	438	146
3° 30'....	51.0	64.5	403	122
4° 00'....	48.0	60	375	94
4° 30'....	45.0	57	356	79
5° 00'....	42.5	54	338	67.5
5° 30'....	41.0	51.5	322	58.5
6° 00'....	39.0	49	306	51
6° 30'....	37.5	47	294	45
7° 00'....	36.0	45.5	284	40.5
7° 30'....	35.0	44.0	275	36.75
8° 00'....	34.0	42.5	268	33.5
8° 30'....	33.0	41.5	259	30.5
9° 00'....	32.0	40.0	250	28
9° 30'....	31.0	39.0	244	25.75
10° 00'....	30.0	38.0	238	23.75
10° 30'....	29.5	37.0	231	22
11° 00'....	29.0	36.5	228	20.75
11° 30'....	28.0	35.5	222	19.5
12° 00'....	27.5	35.0	219	18.25

Table II.—Superelevation 4 ins. Time to run over spiral at maximum allowable velocity 2.72 secs.

Degree of curve.	Velocity balanced by 4 ins. elevation, —miles per hour—	Estimated safe maximum velocity, —miles per hour—	Total lengths of spiral ft.	Feet per 1 degree increase of spiral.
1° 00'....	76.4	105.5	424	424
1° 30'....	62.4	86.0	344	230
2° 00'....	54.0	74.5	298	149
2° 30'....	48.2	67.0	268	107
3° 00'....	44.0	61.0	244	81.5
3° 30'....	40.8	56.4	226	65.0
4° 00'....	38.2	52.7	211	53.0
4° 30'....	36.0	49.8	199	44.0
5° 00'....	34.0	47.1	188	37.5
5° 30'....	32.5	45.0	180	33.0
6° 00'....	31.1	43.1	172	28.5
6° 30'....	29.9	41.4	166	25.5
7° 00'....	28.9	40.0	160	23.0
7° 30'....	27.9	38.5	154	20.5
8° 00'....	27.0	37.3	149	18.5
8° 30'....	26.2	36.2	145	17.0
9° 00'....	25.5	35.2	141	15.5
9° 30'....	24.8	34.3	137	14.5
10° 00'....	24.2	33.4	134	13.5
10° 30'....	23.6	32.6	130	12.5
11° 00'....	23.0	31.8	127	11.5
11° 30'....	22.5	31.0	124	11.0
12° 00'....	22.0	30.4	122	10.0

Table III.—Superelevation 2 ins. Time to run over spiral at maximum allowable velocity 1.36 secs.

Degree of curve.	Velocity balanced by 2 ins. elevation, —miles per hour—	Estimated safe maximum velocity, —miles per hour—	Total lengths of spiral ft.	Feet per 1 degree increase of spiral.
1° 00'....	54.0	90.7	181	181
1° 30'....	44.0	74.0	148	99
2° 00'....	38.2	64.0	128	64
2° 30'....	34.2	57.4	115	46
3° 00'....	31.2	52.5	105	35
3° 30'....	28.9	48.5	97	28
4° 00'....	27.0	45.3	91	23
4° 30'....	25.5	42.8	86	19
5° 00'....	24.1	40.5	81	16
5° 30'....	23.1	38.6	77	14.5
6° 00'....	22.0	37.0	74	12.5
6° 30'....	21.2	35.4	71	11.0
7° 00'....	20.4	34.2	68	9.9
7° 30'....	19.7	33.1	66	8.8
8° 00'....	19.1	32.1	64	8.0
8° 30'....	18.5	31.1	62	7.3
9° 00'....	18.0	30.2	60	6.7
9° 30'....	17.5	29.4	59	6.2
10° 00'....	17.1	28.7	57	5.7
10° 30'....	16.7	28.0	56	5.3
11° 00'....	16.3	27.4	55	5.1
11° 30'....	16.0	26.8	54	4.7
12° 00'....	15.7	26.2	52	4.3

It is very much doubted if the limits of the estimated maximum velocities proposed will be very generally agreed to, and also as to whether or not a grade of 1 in. in 60 ft. is the best that can be found for the ascent of the outer rail in the case on which the whole connection in these tables hinges; but it is suggested that if one such grade is satisfactorily established for a given traffic, the most economical lengths of other spirals on other curves with other velocities and superelevation can best be figured by some process such as is here outlined.

The writer does not believe in the theory held by many intelligent track men, and upheld by Mr. J. I. Boggs, Assoc. M. Am. Soc. C. E., in "Trans. Am. Soc. C. E.," vol. 46, p. 396, that the superelevation of curves "presents at times anomalies, refusing to be bound by printed rules or mathematical equations," nor that individual curves possess "idiosyncrasies" other than those growing out of natural laws fairly well known.

There must be a uniform economic principle connecting the degree of curve, the allowable superelevation, the maximum allowable velocity, and the length of spiral, for a given traffic, which, when properly worked out, will in all cases remove the "curve shock."

The writer very well understands that in making this suggestion he is flying in the face of most of the practice if not the theory in regard to spiral curves. Engineers, in the light of present practice, will look askance at an economic theory that suggests that for the purpose for which a spiral is used, one of shorter length is required for a 12° than for a 4° curve.

However, it cannot be denied that this suggestion is in accord with the fact that the necessity for spiraled curves decreases very rapidly with the velocity. This is true to such an extent that very many roads having curvature so sharp as to form a considerable check on train velocity have not found it necessary to use them.

DIAGRAM FOR DETERMINING SIZE OF RAIN WATER CONDUCTORS AND GUTTERS FOR BUILDINGS.

By Emmett Steece, Assoc. M. Am. Soc. C. E.*

Though in most cases the size of rain water conductors is not of great consequence in the design of a building, yet there are instances when their size and number is an important factor. The writer was requested to furnish the size of conductors for a local building, and upon investigation and study of existing examples, found a wide variation; in fact, over 500% in apparently

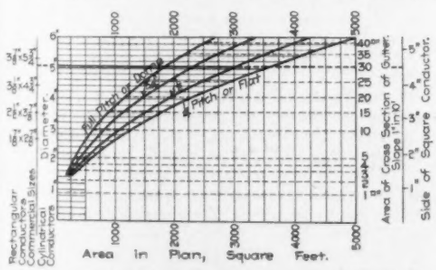


Diagram for Determining the Size of Rain-Water Conductors and Gutters for Buildings.

well-planned modern buildings. It was found, also, that the opinions of architects differed even more than this.

The writer was led to take some observations of the quantity of water discharged from roofs during heavy rains; also, the effect of the slope of roofs, thereon. The close proximity to this office of various buildings having different pitch of roof afforded the writer an excellent opportunity to make a study of the effects referred to.

The heaviest rainfall observed occurred in August, 1898, when the rate of fall was 1.98 ins. per hour. Several heavy rains occurred since, but the rainfall at no subsequent date exceeded 1⅜ ins. per hour.

Though the results of several observations showed some variation, yet they agreed as close as could reasonably be expected. These were plotted and curves drawn, as shown in the accompanying diagram, which is self-explanatory.

The curves are for ¼ pitch, or flat, roofs to full pitch, or domes. The areas are reduced to plan, as shown. The minimum sizes of circular and commercial rectangular conductors are given on the left-hand side of the diagram and the sizes and mimimum cross-sectional area of square gutters on the right-hand side.

To use the diagram: Assume an area of roof, say 30 × 100 ft., or 3,000 sq. ft.; ½ pitch; and one conductor for the whole area. Note the intersection of the vertical line over area 3,000 and the curve of ½ pitch; following thence the horizontal line to the left it strikes a diameter of 5 ins. for circular, or over 3⅛ × 4¾ ins. for commercial size. The next larger size would be used. The mimimum cross-sectional area of gutters is shown on the right to be about 30 sq. ins., and the side of a square conductor about 4.5 ins.

*City Engineer, Burlington, Ia.

OPPORTUNITIES FOR ENGINEERS IN THE NEW POSSESSIONS OF THE UNITED STATES.

The possible opportunities for engineers in the new insular possessions of the United States is an interesting topic to the younger members of the profession; and the following points on this head are taken from an article by Mr. A. W. Buell, C. E., published in "The Polytechnic" of Jan. 25, 1902.

Mr. Buell spent several years in Porto Rico, and he finds a number of conditions there that apply equally well to the Philippines, Hawaii, and to Cuba. These are the importance of the sugar industry, the relative cost of fuel and consequent value of water powers, the transportation problem, including harbor improvements, the tropical climate as a controlling factor in design and material, and the labor employed, the relative cost of material as affecting economic design, and the difficulties of assembling plant and material in these places.

In Porto Rico, there are a number of engineers, graduates of American and foreign engineering schools; and competition is not wanting. As a consequence, engineers must not expect to find conditions of pay and employment much different from what they are here. In these islands, as a rule, the "general practitioner" has advantages over the specialist. The "sugar islands" will probably offer a good field to specialists, however, in developing the construction and maintenance of public highways—under tropical conditions. Porto Rico, with its 3,600 sq. miles, will require 600 to 700 miles of macadam roads, of which about 250 miles are finished. The building of the remainder would mean the expenditure of about $6,000,000, and $500,000 annually for maintenance thereafter. The Hawaiian group has an area of 7,500 sq. miles; the Philippines about 80,000 sq. miles; and Cuba, over 43,000 sq. miles. The proper development of highways in these islands would mean the building of 20,000 or 30,000 miles of improved roads, at a cost of from $200,000,000 to $400,000,000, and $10,000,000 to $15,000,000 for annual maintenance. To finance this expenditure the execution of these roads would have to be extended over 50 to 100 years. But a very respectable number of highway engineers will be in demand in these islands in the near future.

In railway construction the Philippines and Cuba will afford considerable opportunities in time. But harbor improvements promise to be of more immediate importance. Harbor works of considerable magnitude are now under contract in Manila; and in Porto Rico, three or four harbors should be improved at a cost approximating $6,000,000.

Sugar making is a field open for specialists or experts. Cuba can produce annually from 1,000,000 to 1,500,000 tons of sugar; Porto Rico produced 70,000 tons last year, and will more than double this as soon as new factories are built to grind the cane. Hawaii is now a large sugar producer, and the Philippine sugar industry is yet undeveloped. Mr. Buell says that a safe estimate of total investment in sugar in these islands, for the near future, is $400,000,000 to $500,000,000. This will be distributed around, perhaps, 150 central factories, each having an engineer in charge as superintendent. The building of these factories, roads, irrigation works, etc., will employ a number of engineers. This field combines mechanical, civil and chemical engineering; and to gain entrance to this field, a good plan would be to get employment in the drafting room or machine shop of one of the manufacturers of American cane sugar machinery.

The management of cane plantations is a third field; and this includes the cultivation of the cane, irrigation, road-building and improving transport methods from the field to the central factory. The development of water power is another opportunity, of great importance in Porto Rico. Steam coal, in that island, costs $7 to $8 per ton at the wharf. And some ideal sites exist for the development of water power, the generation of electric power, and its transmission over distances not exceeding 10 to 25 miles.

In Spanish countries, the professions of engineering and architecture are generally combined; and a knowledge of architecture will, therefore, be useful to the young engineer.

CONSOLIDATION OF STREET RAILWAY FRANCHISES AT ANTWERP, BELGIUM.

In our issue of Dec. 26, 1901, we gave some particulars of the revision of street railway franchises at Brussels, Belgium, and the International Tramway Union has recently issued particulars of a similar undertaking in the city of Antwerp, from which we take the following particulars.

The tramway system of Antwerp comprised ten lines, aggregating 27¼ miles in length, owned by seven different companies, whose concessions expired at various dates between 1910 and 1932. The lines were operated by horses in a very primitive manner. One of the companies took the initiative in the consolidation, and the Antwerp General Tramways Co. was organized in 1900, to which all the various concessions were transferred. The company then sought powers for building new lines, abandoning others which were useless, and introducing electric traction. The future consolidated system was designed with a view to best serving all parts of the city, and will be about 30 miles in length. Following the precedent established at Brussels, a conference was held between the government and the company, and (after some modifications) was approved in May, 1901, by the Chamber of Representatives and the Senate, and sanctioned by the King. The principal features of the agreement are as follows:

1.—All the concessions will expire on Dec. 31, 1945.

2.—No payment will be made to the State.

3.—Rentals are to be paid to the Province of Antwerp, the city of Antwerp, and the villages traversed, with a minimum equal to the rentals paid by the old companies in 1899. These payments are based upon the gross annual receipts.

4.—The city rates are reduced to a maximum of 3 cts. for any distance, with a minimum fare of 2 cts. The payment of 3 cts. gives the right to a transfer over any connecting line. There will be but one class of fare or car. Workmen during the hours of going to and from work pay only 2 cts. for any distance, and have the right to one change of cars.

5.—The time and conditions under which the authority granting the concession can acquire the concessions and plant by purchase are stipulated.

6.—The fixed plant and rolling stock (except buildings and stations) will be turned over free at the expiration of the concession.

7.—Minimum wages and maximum hours of work are provided, and a retiring pension system is promised by the company.

8.—The company is to convert all the lines to electric traction within four years, the State having the power to require certain changes to ensure that the system of traction will conform to the latest approved methods.

The overhead wire system is authorized, except that in the center of the city the permission of the local authorities must be obtained. The lines will be double-track wherever the traffic and the width of the streets makes it desirable, and will be laid with 86-lb. rails. The motor cars will have transverse seats and large platforms. Three-phase current will be generated at the power station and transmitted to two substations.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
F. P. BURT, - - - TREASURER AND BUSINESS MANAGER.

WM. KENT, E. E. R. TRATMAN, M. N. BAKER, CHAS. S. HILL, } ASSOCIATE EDITORS.

A. B. GILBERT, - - - - - - ASSISTANT MANAGER.
CHAS. W. REINHARDT, - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston. } ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.80 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 322 means that subscription is paid to the 32d week (that is the issue of Aug. 7) of the year 1902; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The decision in the Dayton electrolysis suit, reviewed at some length elsewhere in this issue, while in some respects disappointing to the water and gas fraternities, is nevertheless a signal victory for both the city of Dayton and municipalities at large. The decision recognizes (1) that trolley currents improperly returned to the power house destroy water mains; and (2) that even when a street railway company has a contract with a city for a single overhead trolley system it must use every well-recognized means to keep its currents off the water and gas mains. The city fought hard to secure an order for a change from the single to the double overhead trolley system, or else to the underground conduit system. This, we think, was a mistake. We have always maintained that it is not the duty of a city to say how electrolysis shall be prevented. The burden should rest wholly with the street railway companies. When a city attempts to say how the problem shall be solved it assumes more or less responsibility for the success or failure of the remedy. It may even find to its sorrow that it has entered into a contract, and has thus debarred itself from otherwise possible relief. In the Dayton decision the judge virtually declares that no matter how dangerous the menace from electrolysis, nor how effective a remedy might be found in the double overhead trolley system, the city cannot force the adoption of the latter because it has entered into a contract for the single overhead trolley. In the future, cities will do well to see that their street railway franchises do not cut them off from relief from damages to their own property. In addition, no street railway franchise should be granted hereafter which does not specifically provide that the system shall be so constructed and operated as to return the current to the power house without menace to underground furniture and without any other danger to life or property.

We particularly commend to our readers the valuable paper in this issue by Hon. Theo. E. Burton, Chairman of the House Committee on Rivers and Harbors, on needed reforms in the conduct of river and harbor work. The fact was prominently brought forward in a letter published in our last issue, that the difficulties encountered in the economical and efficient conduct of this class of public works are to be laid to the system itself and to the legislative machinery in connection with it, and not to the officers of the Corps of Engineers who carry out these works in the field.

Of all the reforms which Congressman Burton describes, that which seems of greatest promise and which ought also to be the easiest to bring about is the proposal to create a Board of Engineer Officers to which all the reports of the officers in the field upon projected works should be submitted. Such a board could formulate a general policy to guide in the acceptance and rejection of projects, and, it might even be able to wield so large an influence that it could gradually bring about many of the other reforms which Congressman Burton outlines.

One can imagine a foreigner visiting the United States and being shown the enormous amounts of money spent by the government on river and harbor improvements, and then making a very natural inquiry as to the system on which these expenditures were conducted: "Where do you draw the line between streams and harbors that are worth improvement and those that are not? What proportion is deemed proper between the commerce benefited and the amount of money expended on a given improvement?" The answer to any such query would have to be that no system whatever obtains in these matters. Congress gives a million to this project and ten thousand to that, not at all on the basis of relative needs or commercial requirements; but on the basis of the "push and pull" of local lobbies and of the Congressmen from different localities. The Congressmen themselves are not so much to blame for the "log rolling" system; they are in fact the victims of it. They are judged by their constituents on the basis of the amount of local appropriations secured; and many a man who would rather legislate for the interests of the country at large, is compelled to yield to the prevalent custom and hustle for an appropriation in his own district, which he knows all the time to be a wasteful and unnecessary use of public funds.

It is because this proposed Board of Engineer Officers might finally lead to the extermination of the "log rolling" system, that we hope to see it created. There is a large and growing public sentiment which condemns the "pork barrel" plan of appropriating public funds, and which will welcome and support any system to take its place. The decisions of a rightly constituted Board of Officers would carry such weight with Congress and with the country that it would be a difficult matter to carry appropriations for a project which they had condemned or to turn down a project which they had approved as a necessity.

One of the most important water rights decisions ever rendered was handed down by the U. S. Supreme Court on April 7. Under this ruling waters of an interstate stream may be diverted for public use in one State, regardless of the lower riparian owners in another State. In other words, the decision declares that the right of eminent domain applies to interstate streams. The case at issue involved the right of New York city to use water from the west branch of the Byram River, which rises in New York and flows into Connecticut. The city had expended $1,000,000 or so on a dam and reservoir, and had paid nearly $400,000 for water rights, when two Connecticut farmers secured an injunction in the U. S. Circuit Court, and an affirmation in the U. S. Circuit Court of Appeals, against the use of the reservoir. The city had offered some $20,000 for the land of these farmers, but they refused to settle for less than $125,000. The U. S. Supreme Court annuls the injuction and remands the case to the trial court for a determination of the damages.

This decision means far more to the city of New York than the right to use the water of the Byram River, and the saving of $[illegible] already expended to that end. The city may now proceed without legal hindrance to develop additional water supply from the Ten Mile River, a tributary of the Housatonic, another Connecticut stream, as so ably recommended by Mr. John R. Freeman, M. Am. Soc. C. E., in his recent report to Mr. Bird S. Coler, ex-Comptroller of New York. Mr. Freeman urged, in the face of New York's fiscal talent that there must be some means of overcoming the legal obstacles in the way of developing a water supply for New York city so far surpassing all other sources in availability and economy. Good business sense and New England precedents he believed, would be sufficient to carry the day. Comptroller Coler apparently agreed with him, and doubtless pushed this Byram River suit forward in the highest court with the larger issue in mind. It is gratifying to have the judgment of an eminent engineer so effectively backed by one of the most capable municipal financiers of the country, and then finally affirmed by the Supreme Court of the United States. A few more examples of this sort will do much to blot out that absurd old notion that engineers have no business ability.

WATER PURIFICATION IN THE UNITED STATES.

The constant increase in the number of water purification plants in the United States is one of several indications that municipal health problems are at last beginning to receive something like adequate attention in the more progressive communities of the country. Returns to "The Municipal Year Book" show 243 cities which can be classified under some one of the various methods in vogue for improving the quality of public water supplies. In addition, 68 places merely reported that their water was filtered. If the facts could be known, probably most of these places have nothing better than a very rough or rapid straining, while a few doubtless have efficient purification plants. The returns at hand cover 1,524 cities and towns of 3,000 population and upwards, of which 1,475 report water-works, three make no report on the subject, and 46 state that the communities involved have no public water supplies. Pennsylvania, alone, contains 26, and New York 16 of the 243 purification works, while Pennsylvania also embraces 12 of 68 places which stated that their water was filtered. But Pennsylvania contains 160 of the 1,524 municipalities and 159 of the 1,475 water-works under consideration.

Table I. shows where the various purification plants are located, the populations of the respective cities, the ownership of the water-works, and the kind of purification employed. In a number of cases two or more methods of treatment are combined in one water-works system, while Little Falls, N. Y., and New York city have duplicate, and Denver, Colo., triplicate plants. Where several methods of purification are combined at one place the leading method in use has been counted in making up the following summary:

Mechanical filters, 141; slow sand filters, 21; sedimentation basins, 53; filter galleries, 14; filter cribs, 11; softening plants, 2; aerating plants, 5; total, 247, located in 243 cities and towns.

It may be safely assumed that most of the settling basins and filter cribs effect only a partial clarification, with more or less reduction in bacterial contents. The mechanical filters, also, vary greatly both in efficiency and in the objects for which they were installed. Probably the majority of the mechanical filters were originally designed to remove mud, silt and other suspended matter. This was particularly true of such filters, and of many purification works of other kinds, until within a few years.

A goodly proportion of the mechanical filters installed of late, and nearly all the slow sand filters, are designed primarily to remove bacteria. In proportion to the number of water-works, mechanical filters are most common in the Southern States, and sedimentation basins in the Southwestern States. Nearly all the slow sand filters

are located in the New England and Middle Atlantic States. Softening plants, for municipal water supplies, are just beginning to be built in the United States, each of the two in the list having been put under construction in 1901. Iron removal plants are more common than those for the reduction of hardness, numbering five; but Table I. does not include all the iron removal plants in the United States, whereas only two

TABLE. I.—WATER PURIFICATION IN CITIES AND TOWNS OF 3,000 POPULATION AND UPWARDS BY THE U. S. CENSUS OF 1900.

Towns and cities.	Population, 1900.	Ownership of w.-wks.	Kind of purification.*
Augusta, Me.	11,683	Co.	Mechanical filtration.
Bangor, Me.	21,850	Pub.	Mechanical filtration.
Biddeford, Me.	16,145	Co.	Mechanical filtration.[1]
Brewer, Me.	4,835	Co.	Mechanical filtration.
Calais, Me.	7,655	Co.	Mechanical filtration.
Old Town, Me.	5,763	Co.	Mechanical filtration.
Exeter, N. H.	4,922	Co.	Mechanical filtration.
Somersworth, N. H.	7,023	Pub.	Slow sand filtration.
St. Johnsbury, Vt.	5,666	Co.	Slow sand filtration.[2]
Athol, Mass.	7,061	Co.	Mechanical filtration.
Boston, Mass.	560,892	Pub.	Slow sand filtration.[2]
Lawrence, Mass.	62,559	Pub.	Slow sand filtration.
Milford, Mass.	11,376	Co.	Slow sand filtration.
Nantucket, Mass.	3,006	Co.	Slow sand filtration.
Reading, Mass.	4,969	Pub.	Mechanical filtration.[3]
Woburn, Mass.	14,254	Pub.	Filter gallery.
East Providence, R. I.	12,138	Co.	Mechanical filtration.[2]
Newport, R. I.	22,034	Co.	Mechanical filtration.
Albany, N. Y.	94,151	Pub.	Slow sand,aeration & sedimentation
Binghamton, N. Y.	39,647	Pub.	Mechanical filtration.
Elmira, N. Y.	35,672	Co.	Mechanical filtration.
Hornellsville, N. Y.	11,918	Pub.	Mechanical filtration.
Hudson, N. Y.	9,628	Pub.	Slow sand filtration.
Ilion, N. Y.	5,138	Pub.	Slow sand filtration.
Kingston, N. Y.	24,535	Pub.	Mechanical filtration.
Little Falls, N. Y.	10,381	Pub.	Aerated,[2] slow sand filtration.[2]
Middletown, N. Y.	14,522	Pub.	Mechanical filtration.
Mt. Vernon, N. Y.	21,228	Co.	Slow sand filtration.
New York, N. Y.	3,437,202	Pub.	Mechanical filtration.[2]
		Co.	Slow sand filtration.[2 3]
Niagara Falls, N. Y.	19,457	Pub.	Mechanical filtration.
		Co.	
Nyack, N. Y.	4,275	Pub.	Slow sand filtration.[2]
Owego, N. Y.	5,039	Co.	Mechanical filtration.
Port Chester, N. Y.	7,440	Co.	Mechanical filtration.
Poughkeepsie, N. Y.	24,029	Pub.	Slow sand filtration.
Rensselaer, N. Y.	7,466	Co.	Mechanical filtration.
Asbury Park, N. J.	4,148	Pub.	Mechanical filtration.
Bordentown, N. J.	4,110	Co.	Mechanical filtration.
Hoboken, N. J.	59,364	Joint.	Aerated at times.
Keyport, N. J.	3,413	Pub.	Mechanical filtration.[2]
Lambertville, N. J.	4,637	Co.	Slow sand filtration.
Long Branch, N. J.	8,872	Co.	Mechanical filtration.
Paterson, N. J.	105,171	Co.	Mechanical filtration.[1]
Salem, N. J.	5,811	Pub.	Slow sand filtration.
Somerville, N. J.	4,843	Co.	Mechanical filtration.
Allegheny, Pa.	129,896	Pub.	Filter crib.
Beaver Falls, Pa.	10,654	Co.	Mechanical filtration.
Carlisle, Pa.	9,626	Joint.	Mechanical filtration.
Chester, Pa.	33,988	Co.	Sedimentation and coagulation.
Danville, Pa.	8,042	Pub.	Mechanical filtration.
Etna, Pa.	5,384	Pub.	Filter crib.
Gettysburg, Pa.	3,495	Co.	Mechanical filtration.
Knoxville, Pa.	3,511	Co.	Filter crib.
Media, Pa.	3,075	Pub.	Mechanical filtration.
Middletown, Pa.	5,608	Co.	Slow sand filtration.(?)
Millvale, Pa.	6,736	Pub.	Filter crib.
		Co.	
Monongahela, Pa.	5,173	Co.	Filter gallery.
New Brighton, Pa.	6,820	Co.	Mechanical filtration.
New Castle, Pa.	28,339	Co.	Mechanical filtration.
New Kensington, Pa.	4,665	Co.	Filter crib.
Norristown, Pa.	22,265	Co.	Mechanical filtration.
Philadelphia, Pa.	1,293,697	Pub.	Slow sand filtration.[2]
Phoenixville, Pa.	9,196	Pub.	Sedimentation.
Sewickley, Pa.	3,568	Pub.	Filter crib.
Sharon, Pa.	8,916	Co.	Mechanical filtration.
Washington, Pa.	7,670	Co.	Softening plant.[1]
Waynesboro, Pa.	5,390	Co.	Softening plant.[1]
West Chester, Pa.	9,524	Pub.	Sedimentation.(?)
Wilkesbarre, Pa.	51,721	Co.	Mechanical filtration.[2]
Wilkinsburg, Pa.	11,886	Co.	Filter crib.
York, Pa.	33,708	Co.	Mechanical filtration.
Wilmington, Del.	76,508	Pub.	Special.*
Fredericksburg, Va.	5,068	Pub.	Sedimentation.
Norfolk, Va.	46,624	Pub.	Mechanical filtration.
Petersburg, Va.	21,810	Pub.	
		Co.	Mechanical filtration.[3]
Benwood, W. Va.	4,511	Co.	Mechanical filtration.
Clarksburg, W. Va.	4,050	Pub.	Sedimentation.
Fairmont, W. Va.	5,655	Pub.	Mechanical filtration.
Huntington, W. Va.	11,923	Co.	Mechanical filtration.
Asheville, N. C.	14,694	Pub.	Mechanical filtration.
Charlotte, N. C.	18,091	Pub.	Mechanical filtration.
Durham, N. C.	6,679	Co.	Mechanical filtration.
Gastonia, N. C.	4,610	Pub.	Mechanical filtration.
Goldsboro, N. C.	5,877	Pub.	Mechanical filtration.
Greensboro, N. C.	10,035	Co.	Mechanical filtration.[1]
Henderson, N. C.	3,746	Co.	Mechanical filtration.
Raleigh, N. C.	13,643	Co.	Mechanical filtration.
Salisbury, N. C.	6,277	Pub.	Mechanical filtration.
Winston, N. C.	10,008	Pub.	
Salem, N. C.	3,642	Co.	Mechanical filtration.[3]
Columbia, S. C.	21,108	Pub.	Mechanical filtration.
Union, S. C.	5,400	Pub.	Mechanical filtration.
Athens, Ga.	10,245	Pub.	Mechanical filtration.
Atlanta, Ga.	89,872	Pub.	Mechanical filtration.
Augusta, Ga.	39,441	Pub.	Mechanical filtration.
Columbus, Ga.	17,614	Co.	Sedimentation.
La Grange, Ga.	4,274	Co.	Mechanical filtration.
Macon, Ga.	23,272	Co.	Mechanical filtration.
Milledgeville, Ga.	4,219	Co.	Mechanical filtration.
Rome, Ga.	7,291	Pub.	Mechanical filtration.
Jacksonville, Fla.	28,429	Pub.	Aerated.
		Co.	
Birmingham, Ala.	38,415	Co.	Sedimentation.
Eufaula, Ala.	4,532	Pub.	Mechanical filtration.
Gadsden, Ala.	4,282	Co.	Mechanical filtration.
Columbus, Miss.	6,484	Pub.	Mechanical filtration.
Vicksburg, Miss.	14,834	Co.	Sedimentation.
Shreveport, La.	16,013	Co.	Sedimentation; mechanical filtration
Chattanooga, Tenn.	30,154	Co.	Sedimentation; mechanical filtration
Clarksville, Tenn.	9,431	Pub.	Mechanical filtration.
Knoxville, Tenn.	32,637	Co.	Mechanical filtration.
Nashville, Tenn.	80,865	Pub.	Filter gallery.
Ashland, Ky.	6,800	Co.	Sedimentation.
Catlettsburg, Ky.	3,081	Co.	Sedimentation.
Covington, Ky.	42,938	Pub.	Sedimentation.
Danville, Ky.	4,285	Pub.	Mechanical filtration.
Frankfort, Ky.	9,487	Co.	Sedimentation.
Hopkinsville, Ky.	7,290	Co.	Mechanical filtration.
Lexington, Ky.	26,369	Co.	Mechanical filtration.
Louisville, Ky.	204,731	Pub.	Sedimentation[1]; mechanical filtratn[1]
Mt. Sterling, Ky.	3,561	Co.	Mechanical filtration.
Newport, Ky.	28,301	Pub.	Sedimentation.
Shelbyville, Ky.	3,016	Co.	Mechanical filtration.
Winchester, Ky.	5,964	Co.	Mechanical filtration.
Alliance, O.	8,974	Pub.	Sedimentation.
Bucyrus, O.	6,560	Co.	Mechanical filtration.
Circleville, O.	6,991	Co.	Filter gallery.(?)
Conneaut, O.	7,133	Co.	Mechanical filtration.
Dennison, O.	3,763	Co.	Mechanical filtration.
Lorain, O.	16,028	Pub.	Mechanical filtration.
Newark, O.	18,157	Co.	Mechanical filtration.[1]
Norwalk, O.	7,074	Pub.	Sedimentation.
Oberlin, O.	4,082	Pub.	Sedimentation.
Painsville, O.	5,024	Pub.	Filter gallery.(?)
Pomeroy, O.	4,639	Co.	Sedimentation; filtered.
Upper Sandusky, O.	3,355	Co.	Sedimentation; filtered.
Warren, O.	8,529	Co.	Mechanical filtration.
Wellston, O.	8,045	Pub.	Sedimentation.
Columbus, Ind.	8,130	Pub.	Filter crib.
Greencastle, Ind.	3,661	Co.	Filter gallery.(?)
Muncie, Ind.	20,942	Co.	Mechanical filtration.
New Albany, Ind.	20,628	Co.	Aerated.
Sullivan, Ind.	3,118	Pub.	Mechanical filtration.
Terre Haute, Ind.	36,673	Co.	Sedimentation; mechanical filtration
Vincennes, Ind.	10,249	Co.	Mechanical filtration.
Warsaw, Ind.	3,987	Co.	Mechanical filtration.
Washington, Ind.	8,351	Co.	Filter crib.(?)
Adrian, Mich.	9,654	Co.	Mechanical filtration.
Grand Rapids, Mich.	87,565	Pub.	Sedimentation.
		Co.	
Ironwood, Mich.	9,705	Co.	Mechanical filtration.
Mount Clemens, Mich.	6,576	Pub.	Mechanical filtration.
St. Joseph, Mich.	5,155	Pub.	Filter crib.(?)
Alton, Ill.	14,210	Co.	Mechanical filtration.
Belleville, Ill.	17,484	Co.	Mechanical filtration.(?)
Cairo, Ill.	12,566	Co.	Sedimentation; mechanical filtration
Decatur, Ill.	20,754	Pub.	Mechanical filtration.
East St. Louis, Ill.	29,655	Co.	Mechanical filtration.
Elgin, Ill.	22,433	Pub.	Mechanical filtration.
Kankakee, Ill.	13,595	Co.	Sedimentation; mechanical filtratn[1]
Murphysboro, Ill.	6,463	Co.	Mechanical filtration.
Pontiac, Ill.	4,266	Co.	Mechanical filtration.
Quincy, Ill.	36,252	Co.	Mechanical filtration.
Rock Island, Ill.	19,493	Pub.	Slow sand filtration.
Springfield, Ill.	34,159	Pub.	Filter galleries.
Streator, Ill.	14,079	Co.	Mechanical filtration.
Appleton, Wis.	15,085	Co.	Mechanical filtration.
Ashland, Wis.	13,074	Co.	Slow sand filtration.
Manitowoc, Wis.	11,786	Co.	Filter gallery.
Marinette, Wis.	16,195	Co.	Mechanical filtration.
Merrill, Wis.	8,537	Co.	Mechanical filtration.
Oshkosh, Wis.	28,284	Co.	Mechanical filtration.
Stevens Point, Wis.	9,524	Co.	Mechanical filtration.
Superior, Wis.	31,091	Co.	Slow sand filtration[2]; aeration.[3]
Burlington, Ia.	23,201	Co.	Mechanical filtration.
Cedar Rapids, Ia.	25,656	Co.	Mechanical filtration.
Council Bluffs, Ia.	25,802	Co.	Sedimentation.
Creston, Ia.	7,752	Co.	Mechanical filtration.
Davenport, Ia.	35,254	Co.	Sedimentation; mechanical filtration
Des Moines, Ia.	62,139	Co.	Filter gallery.
Dubuque, Ia.	36,297	Pub.	Mechanical filtration.[4]
Fort Dodge, Ia.	12,162	Pub.	Filter gallery.(?)
Iowa City, Ia.	7,987	Co.	Filter crib.
Keokuk, Ia.	14,641	Co.	Mechanical filtration.
Mt. Pleasant, Ia.	4,109	Pub.	Mechanical filtration.(?)
Muscatine, Ia.	14,073	Pub.	Sedimentation.(?)
Oskaloosa, Ia.	9,212	Co.	Mechanical filtration.
Ottumwa, Ia.	18,197	Co.	Mechanical filtration.
Waterloo, Ia.	12,580	Co.	Mechanical filtration.
Brainerd, Minn.	7,524	Co.	Mechanical filtration.
Argentine, Kan.	5,878	Co.	Sedimentation.
Atchison, Kan.	15,722	Co.	Sedimentation.
Coffeyville, Kan.	4,953	Pub.	Sedimentation.
Fort Scott, Kan.	10,322	Co.	Sedimentation.
Horton, Kan.	3,398	Co.	Mechanical filtration.
Independence, Kan.	4,851	Co.	Mechanical filtration.
Iola, Kan.	5,791	Pub.	Coagulation and sedimentation.
Kansas City, Kan.	51,418	Co.	Sedimentation; mechanical filtration
Lawrence, Kan.	10,862	Co.	Sedimentation;[3] mech'l filtration.[3]
Leavenworth, Kan.	20,735	Co.	Sedimentation.
Osawatomie, Kan.	4,191	Pub.	Mechanical filtration.
Ottawa, Kan.	6,934	Co.	Sedimentation.
Paola, Kan.	3,144	Co.	Mechanical filtration.
Parsons, Kan.	7,682	Co.	Mechanical filtration.(?)
Wellington, Kan.	4,245	Pub.	Sedimentation.
Winfield, Kan.	5,554	Co.	Mechanical filtration.
Nebraska City, Neb.	7,380	Co.	Mechanical filtration.
Omaha, Neb.	102,555	Co.	Sedimentation.
Plattsmouth, Neb.	4,964	Co.	Sedimentation.(?)
Bismarck, N. Dak.	3,319	Co.	Sedimentation.
Grand Forks, N. Dak.	7,652	Pub.	Slow sand filtration.
Cheyenne, Wyo.	14,087	Pub.	Filter galleries.(?)
Boonville, Mo.	4,377	Co.	Sedimentation.
Cape Girardeau, Mo.	4,815	Co.	Sedimentation.
Carthage, Mo.	9,416	Co.	Sedimentation.
Columbia, Mo.	5,651	Co.	Sedimentation.
Hannibal, Mo.	12,780	Co.	Sedimentation.
Independence, Mo.	6,974	Co.	Sedimentation.
Joplin, Mo.	26,023	Co.	Mechanical filtration.
Kansas City, Mo.	163,752	Pub.	Sedimentation and coagulation.[4]
Kirksville, Mo.	5,966	Pub.	Sedimentation.
Louisiana, Mo.	5,131	Co.	Mechanical filtration.
Mexico, Mo.	5,099	Co.	Mechanical filtration.(?)
Rich Hill, Mo.	4,683	Co.	Mechanical filtration.
St. Charles, Mo.	7,982	Pub.	Sedimentation.[1]
St. Joseph, Mo.	102,979	Co.	Mechanical filtration.
St. Louis, Mo.	575,238	Pub.	Sedimentation.
Sedalia, Mo.	15,231	Co.	Mechanical filtration.
Washington, Mo.	3,915	Co.	Sedimentation; mechanical filtration
Fort Smith, Ark.	11,587	Co.	Sedimentation.
Little Rock, Ark.	38,307	Co.	Sedimentation.
Austin, Tex.	22,258	Pub.	Filter galleries.
		Co.	
Dallas, Tex.	42,638	Pub.	Sedimentation.
Fort Worth, Tex.	26,688	Pub.	Sedimentation.
Greenville, Tex.	6,800	Co.	Sedimentation; mechanical filtration
Colorado Springs, Colo.	21,085	Pub.	Sedimentation and screening.
Denver, Colo.	133,859	Co.	Sedimentation; mech. fil.; filter gal.
Grand Junction, Colo.	3,503	Pub.	Sedimentation.
Pueblo, Colo.	28,157	Pub.	
		Co.	Sedimentation.[5]
Trinidad, Colo.	5,345	Pub.	Sedimentation.
Walla Walla, Wash.	10,049	Pub.	Filter gallery.[2]
Oregon City, Ore.	3,494	Pub.	Mechanical filtration.
Berkeley, Cal.	13,214	Co.	Mechanical filtration.
Eureka, Cal.	7,327	Co.	Mechanical filtration.
Oakland, Cal.	66,960	Co.	Mechanical filtration; aeration.
Riverside, Cal.	7,973	Co.	Mechanical filtration.[2]
San Francisco, Cal.	342,782	Co.	Aerated; strained.[4]
Provo City, Utah.	6,185	Pub.	Sedimentation.

*Classified as mechanical filtration in summaries.
[1]Under construction. [2]Part of city, only. [3]To remove iron. [4]At times. [5]Not stated whether purification plant is a part of the city's or the company's works.

municipal water softening plants have yet been established in this country. Slow sand filtration is employed to remove iron in three, and mechanical filtration in two of the five cases.

The third column of Table I. shows that a large majority of the mechanical filtration plants are owned by water companies, the approximate proportion being 100 private to 40 public plants. The slow sand filters are more evenly divided, city ownership here being slightly in the lead. Grouping together everything outside these two methods of purification, it appears that the division of ownership is almost equal. These figures do not bear out the common assumption that municipalities are more careful than private companies to supply pure water to their consumers. But neither do they, alone, prove the contrary. A careful analysis of local conditions would doubtless throw some light on this interesting question, but neither the space nor information here available will permit going into the subject as exhaustively as would be required to arrive at a just conclusion as to why private companies have installed more mechanical filters than have municipalities. Two possible reasons, however, may be mentioned: (1) The greater prevalence of private ownership in the particular sections where mechanical filters have been set up; and (2) a strong popular feeling against the purchase of certain classes of patented articles by municipalities, particularly such, as in this case, as have been the subject of much litigation between rival proprietors. It may also be added that until quite recently the sanitary efficiency of mechanical filters was not established, and engineers were slow to advise their adoption by municipalities.

While it is true that very few of the larger cities of the country are supplied with filtered water, it is interesting to note that of the 37 places having a population of more than 100,000, 18 are either treating a part or all of their supply in some fashion, or else are taking steps to do so. At New York and Boston small portions of the water supply, which would otherwise be objectionable or dangerous, are purified, as shown in Table I. At Kansas City and Omaha settling basins are employed; at Denver, sedimentation, mechanical filtration, and filter galleries are in use; and at Allegheny, Pa., the supply is from filter cribs in the Allegheny River. Philadelphia, Cincinnati, Louisville and Paterson will, in a few years, be supplied from purification works already under construction. The cities of Pittsburg and New Orleans, Washington, or the District of Columbia, and the company that supplies Indianapolis, have decided to build purification works. At St. Louis, Minneapolis, Providence and Columbus there has been much agitation for water purification for many years past, but nothing definite has yet been accomplished.

Besides the places named above as having water purification works projected, there may be added, regardless of size, Watertown, N. Y., Henderson, Ky., Moline, Ill., and Richmond, Mo. Doubtless many other places would be added to the list if the facts were at hand.

As a matter of convenience to those wishing a list of all the places reporting some sort of water purification, and in justice to a few communities that doubtless would be included in Table I., if details were available, the 68 cities classed as having filtered water supplies are given in Table II.:

TABLE II.—List of Cities Reporting Their Water Supplies as Filtered, but Not Giving the Method Employed.

Bath, Me.;	Butler, Pa.;	Paducah, Ky.;	Emporia, Kan.;
Brunswick, Me.;	Catasauqua, Pa.;	E. Liverpool, O.;	Billings, Mont.;
Ellsworth, Me.;	Charleroi, Pa.;	Findlay, O.;	Boonville, Mo.;
Houlton, Me.;	Connellsville, Pa.;	Fostoria, O.;	Lexington, Mo.;
Saco, Me.;	Conshohocken, Pa.;	Steubenville, O.;	Marysville, Mo.;
Derry, N. H.;	Huntingdon, Pa.;	Bloomington, Ind.;	Fayetteville, Ark.;
Littleton, N. H.;	Indiana, Pa.;	Mt. Vernon, Ind.;	Hot Springs, Ark.;
Pembroke, N. H.;	Nanticoke, Pa.;	Red Jacket, Mich.;	Cameron, Tex.;
Adams, Mass.;	Quakertown, Pa.;	Carlinville, Ill.;	Denison, Tex.;
Braintree, Mass.;	Sunbury, Pa.;	Effingham, Ill.;	Elmo, Okla.;
Northbridge, Mass.;	Tarentum, Pa.;	Granite, Ill.;	Canyon City, Colo.;
Peabody, Mass.;	New Castle, Del.;	Olney, Ill.;	Cripple Creek, Colo.
Wareham, Mass.;	Cambridge, Md.;	Portage, Wis.;	Florence, Colo.;
Whitman, Mass.;	Charleston, W. Va.;	Cedar Falls, Ia.;	Fort Collins, Colo.;
Pawtucket, R. I.;	Fayetteville, N. C.;	Knoxville, Ia.;	Aberdeen, Wash.;
Seneca Falls, N. Y.;	Gainsville, Ga.;	Crookston, Minn.;	Salem, Wash.;
Bloomsburg, Pa.;	Opelika, Ala.;	Chanute, Kan.;	Los Angeles, Cal.

More definite information regarding the character of filtration practiced at any of the foregoing places would be very acceptable. Should it be shown that a considerable number of these 68 places belong in the list of water purification plants, the number of the latter would be sufficiently raised to include one-fifth of all the cities and towns of 3,000 population in the United States which enjoy public water supplies. Although many of the places composing this possible one-fifth have quite imperfect purification works, it is nevertheless very encouraging to know that the importance of pure water is becoming so generally recognized.

LETTERS TO THE EDITOR.

Priming Centrifugal Pumps.

Sir: Relative to Mr. R. S. Prindle's letter in your issue of April 3, on the subject of priming centrifugal pumps, I would offer the following remarks:

1. When the priming pipe is connected with the dredge pump on the discharge or pressure zone there is nothing to prevent the dredge pump, if running, from discharging more or less water over into the primer at the moment when the priming operation is about completed and when the speed of the dredge pump is sufficient to overcome the head. For this reason alone, therefore, it is obviously desirable to have the primer operated separately. The writer is familiar with the sand pumping plant installed in Brooklyn which Mr. Prindle refers to, and knows positively that the barrel of the priming pump was badly scored, and that, though the pump was but little used, it required to be overhauled at comparatively frequent intervals.

2. To secure positive priming it is always desirable to take the air out at the highest point of the pump, this being usually the top of the volute and not the suction elbow.

3. Where a good priming pump is installed with tight piping, and a vacuum of 27 to 28 ins. is liable to be formed, it is safer to have the priming pipe carried up more than 30 ft. above the water level, as there will be some surging of water in the pipe; thus some water might get over into the horizontal pipe and from there into the primer, and a very small quantity of sand or grit will impair the efficiency of the latter.

4. It is necessary to run these rotary pumps which Mr. Prindle refers to at very high speeds in order to get a good vacuum, as their construction is such that some leakage is inevitable. Yours truly,

E. F. Doty, Camden Iron Works.

Camden, N. J., April 7, 1902.

The Relative Cost of Macadam Roads at Port Huron, Mich., and Hudson, N. Y.

Sir: In your issue of March 6, 1902, Mr. Frank F. Rogers' paper on "Cost of Building Macadam Roads at Port Huron, Mich.," is given in abstract, and at the end of the paper there is a comparison of cost at Port Huron with that of Hudson, N. Y., as given by Mr. H. K. Bishop in your issue of Jan. 9, 1902. The comparison is an entirely unjust one to the work described by Mr. Bishop, for while Mr. Rogers' unit of measure is the cubic yard of loose stone, Mr. Bishop's unit is the square yard of rolled macadam (6 ins. thick after rolling). In order to reduce a cubic yard of compacted material to a cubic yard of loose stone, Mr. Rogers multiplies by 1.25, and herein lies his error, an error that I may add is to be found in Byrne's "Highways" and in many other works. In "Economics of Road Construction" I have given the true factor to be used in such reductions, and it is 1.6 instead of 1.25, where screenings as well as large stone are included in the loose measure, as was the case at Hudson. Applying this correct factor we find that the cost of hauling a loose yard of stone, for example, was (at Hudson) about 35 cts. for 1½-mile haul and not 43.87 cts., as computed by Mr. Rogers, and a like difference of course exists in all the other items. Mr. Rogers' use of a steam roller to haul five dump wagons loaded with stone is a commendable move in the right direction, but I think he has overestimated the cost of hauling stone by teams, for he says it would have required five teams to haul 76 cu. yds. of stone in 10 hours, the lead being ¾ mile. The actual time of a team traveling ¾ mile and return is 35 minutes, and ordinarily 5 minutes at each end for loading and dumping is the additional time consumed, making a total of 45 minutes per round trip, or 13 trips in 10 hours, with 15 minutes to spare. On a level earth road 1½ cu. yds. of stone is a fair load, so four teams would readily haul the maximum output of 76 cu. yds. With teams at $3.50 a day, the cost of hauling a cubic yard is therefore 19 cts.; but if the haul is made over the portion of the macadam already built a load of 2½ to 3 cu. yds. may be hauled by a team at a cost of less than the 13 cts. by the roller-hauling method employed by Mr. Rogers. There is nevertheless a feature decidedly favorable to the roller method, and that is the smallness of the force necessary, which is always a desideratum. Moreover, as stated by Mr. Rogers, the roller during hauling is also rolling the road and improving it. Yours truly,

H. P. Gillette.

Rochester, N. Y., April 10, 1902.

(In our issue of March 13, Mr. Bishop also criticised Mr. Rogers' comparative figures.—Ed.)

Notes and Queries.

N. W., Dallas, Tex., writes:

In response to inquiry of J. B. B., of San Francisco, Cal. (Eng. News, March 20, p. 233), I beg to state that the coefficient of friction between steel and ice has been given as varying from 0.014 to 0.027; between ice and ice, between 0.018 and 0.028.

R. S. asks us to give the most correct method of sounding and computing dredged material in situ; in a basin 1,000 ft. long by 375 ft. wide, with side and end slopes of 1 on 2. The material is of a rock nature and there is about 6 ft. cutting; depth of water not stated. There are various methods of computing this material; all founded on the principle of an accurate survey of the elevation of the original surface, and the final survey of the bottom, as called for by the specifications. As this is a question frequently raised and upon which there is little or no literature as to detailed methods, we would suggest correspondence on this head by those having actual experience in this class of engineering work.

Concerning the recent discussion of the method of making masonry water-tight by grouting, a correspondent refers us to Engineering News of Nov. 17, 1888, p. 383. The article to which the reference relates is entitled "How to Build Earth Dams with Perfect Safety," and is based on data compiled from the note book of the late Wm. J. McAlpine. The paragraph relating to grouting is as follows:

Long experience and careful experiments have proved that if tight and substantial work is aimed at, grouting must be done with good cement alone. If sand is used with the cement, it separates from the cement, the mixture ceases to be mortar and the sand blocks the channels and prevents the flow of the grout to the lower or distant cavities, and leaves above the obstruction a layer of practically pure sand covered by purer cement. During the construction of the Brooklyn Dry Dock, nearly 40 years ago, grouting was prohibited by Mr. McAlpine, Engineer in Chief, although the reverse was then the almost universal practice of the government engineers. A commission was appointed to investigate the effect of this departure, among others, from the then approved practice, and Maj. R. E. Lee, one of the commission, had built under his personal inspection a section of dry wall, carefully chinked and as carefully grouted. When this wall was torn down the condition of things above described was found, unfilled cavities below, sand above and pure cement on top, just as the Engineer in Chief had foretold.

F. S. asks the following:

Will you kindly inform me if the equation for horizontal thrust on the column of a freight or passenger shed, as given by Mr. Leopold Mensch in your issue of Feb. 1, 1900, is scientifically correct, or is an approximation?

Our correspondent will note a correction to Mr. Mensch's letter in our issue of March 29, 1900, in which Mr. Mensch repeats his formula in "corrected" form. This "correction" contains itself an error, as will appear by comparison with the expression given below. In the same issue, March 29, 1900, another correspondent calls attention to a mistake in the drawings illustrating Mr. Mensch's letter. The sketch shown at a, Fig. 1, should show the bottom of the posts forming a deflection angle with the vertical, as the demonstration employed by Mr. Mensch assumes a point-bearing at the column bases.

As regards the present question, is the formula developed an exact one or an approximation? several facts must be borne in mind. Firstly, the demonstration rests throughout on the "common theory of flexure;" the assumptions made in this are well known, as are also the usual limits of the involved error. Secondly, in the adaptation of the treatment to the case of a roof truss framed to columns at its ends, there appear several assumptions of considerable weight; thus, the roof truss is assumed to have a uniform moment of inertia for its full length, with a neutral axis lying in a straight line; the columns are supposed to take no moment at their bases, i. e., to have a point-bearing. Aside from these latter assumptions, the equation may be said to be exact, inasfar as the theory of flexure is exact. It is important to remember, however, that the present case of application of this theory is less exact than the application to an ordinary beam or girder. One of the assumptions made in the "common theory of flexure" is that the shear deformations are neglected, and while this involves no appreciable error in the case of a solid beam or a plate girder, it is

considerably in error in the case of trusses or other open-web structures.

Referring to the mathematical work in Mr. Mensch's letter, it is necessary to remark that while the method followed is correct, there are serious typographical and other errors in the work, which make it quite difficult to follow through. As noted above, the "correction" by Mr. Mensch in our issue of March 29, 1900, also contains an error, probably a typographical error. As correctly worked through, the formula should read, if put into the form used by Mr. Mensch:

$$X = \frac{l}{h} \cdot \frac{\frac{3}{4} p h^3 \left(1 + \frac{11}{18} \cdot \frac{h}{l} \cdot \frac{I}{I_1}\right) - \frac{1}{12} p_1 l^3}{1 + \frac{2}{3} \cdot \frac{h}{l} \cdot \frac{I}{I_1}};$$

where h = height from floor to neutral axis of truss.
l = length of span.
p_1 = load on truss per foot of span.
p = wind load on side per foot of height of column.
I = moment of inertia of truss.
I_1 = moment of inertia of column, the two columns being of the same section.

BOOK REVIEWS.

THE COST OF FOOD: A STUDY IN DIETARIES.—By Ellen H. Richards, Instructor in Sanitary Chemistry, Massachusetts Institute of Technology. New York: John Wiley & Sons. Cloth; 6 x 8 ins.; pp. 161; tables.

With the exception of professional cooks, such a book as this should appeal at least as forcibly to engineers as to any class of men, since its text is how best to utilize some of the great forces of nature in the service of man. The first part of the volume discusses the food-needs of persons of different ages and occupations and the second takes up dietaries designed to cost from 10 to 60 cts. per day per person. This discussion is followed by a dietary computer and a selected bibliography.

HAND-BOOK ON SANITATION.—A Manual of Theoretical and Practical Sanitation. For Students and Physicians; for Health, Sanitary, Tenement-House, Plumbing, Factory, Food and Other Inspectors; as well as for Candidates for all Municipal Sanitary Positions. By Geo. M. Price, M. D., Medical Sanitary Inspector, Department of Health, New York City. New York: John Wiley & Sons. Cloth; 5 × 7 ins.; pp. 317; 30 illustrations. $1.50.

Among the topics treated in this volume are building sites, ventilation, warming, water supply, sewerage and plumbing. These chapters fall under what the author terms "Sanitary Science," and may often be characterized as descriptive rather than discriminating. The next group of chapters, under the general heading "Sanitary Practice," describes, often in the briefest possible outline, the problems to be met by various classes of inspectors and gives some excellent quotations from sanitary regulations. The nine chapters on "Sanitary Inspection" are mostly of a general nature, but the author here says some excellent things about the qualifications of health inspectors, outlines the points to be noted in tenement-house inspections and reports thereon, and gives a few elementary tables. The concluding section, on "Sanitary Law," is in many respects the most valuable one in the book, because it is composed almost wholly of quotations from state and local laws and ordinances regulating tenement houses, plumbing and the like, founded on years of study by competent authorities and full of specific and practical information. All this matter, outside of that relating to New York state and city, and some other portions of the book, also, are taken (with proper credit) from the recent large work by Dr. Chas. V. Chapin, on "Municipal Sanitation in the United States."

Aside from these extracts most of the volume is too vague and general to be of great service to inexperienced sanitary agents, while the same qualities, combined with the elementary treatment of many sections, render all but the extracts of comparatively little value to men at all well equipped for their work. The section devoted to "Sanitary Science" contains some of those misleading and erroneous statements relating to sanitary engineering and biology to which medical practitioners and writers are so prone. But after all, it must be remembered that the attempt to provide a hand-book suitable for any one of the classes named on the title page is a difficult one, while to render adequate service to all of them is next to impossible in one small volume. Much of the space, however, might have been used to far better advantage.

THE INDICATOR HANDBOOK.—A Practical Manual for Engineers. By Chas. N. Pickworth, Editor of "The Mechanical World." Part II., The Indicator Diagram: Its Analysis and Calculation. Cloth; 5 × 7 ins.; pp. 128; 148 illustrations; 1 table. New York: D. Van Nostrand Co., Price, $1.50.

This volume completes the treatment of the subject which was introduced in the first part, issued about three years ago. The first volume described the indicator, its accessories, and its method of use, dealing at some length with errors arising from the construction of the instrument and from faulty manipulation. The present volume considers the indicator diagram and its interpretation. After an introductory chapter which takes up in a brief and general way the matter of expansion of gases, separate chapters are devoted to: a general explanation of the make-up of the diagram, the analysis of the diagram with reference to the action of the engine, diagrams from multiple-expansion engines, diagrams from internal combustion engines, from air-compressors, pumps, etc., and the calculation connected with indicator diagrams; an appendix shows how to determine the index of any expansion or compression curve. The treatment is, throughout, very clear and complete, and at the same time remarkably concise. The subject matter is far less familiar to those who should have mastered it than is that of Part I.; the present volume may be read with profit and used advantageously as a reference even by those who have not read the preceding volume.

STANDARDS FOR STRUCTURAL DETAILS.—American Bridge Co., Engineering Department; C. C. Schneider, Vice-President; Paul L. Wolfel, Chief Engineer. 1901. Cloth; 6½ x 10 ins.; 95 pp. of tables, drawings and text; 6 pp. of appendix.

After being in preparation for a long period of time, this volume has at last made its appearance. Its purpose and intended scope are stated in the preface thus:

In order to obtain uniformity in the work done at the various plants of the American Bridge Co. it has been deemed advisable to prepare a system of standards for use in every engineering office to assist the engineers and draftsmen, in making detail and shop drawings. . . . They also contain such useful tables and information as will be found convenient in every engineering office where steel work is being designed.

It appears that the present volume was prepared mainly from the "Standards" of the various bridge companies which combined to form the American Bridge Co., and that the engineers of the different plants contributed suggestions as to its make up.

Such a book has for some time been a pressing necessity in this country. Details and methods in steel construction work have gradually tended toward standardization and uniformity, a tendency which became more marked with the remarkable growth of the use of shape steel in bridge, building and general construction work. The great advantage to America that has resulted from the early adoption of a simple and well-devised set of standards for steel shapes is only in late years being fully realized by engineers; similar advantages should result from the general adoption of standards for design and detailing in steel construction, advantages that will be appreciated by every one familiar with the present diversity in such work in this country. With the formation of the American Bridge Co., some such code of standard practice was at once required to systematize the work at its various plants and the present volume appeared in consequence.

The expectations which, based on these facts, would naturally be entertained as to the contents and scope of the book, are, most of them, disappointed by an examination of its pages. The following brief review of the contents of the book will render this apparent.

The first 15 pages are devoted to tables of weights and sizes of structural shapes, giving also the standard framing for beams and channels. The "properties" of the sections, i. e. values of c, I and r, are not given. A peculiar list of channels appears on p. 4, stated to be used in bridge work; the sections appear to be heavier than the regular sections, with wider flanges, and of apparently quite arbitrary weights per foot. It may be remarked that all the shapes shown or listed are (with the exception of 24-in. beams) those made at the Pencoyd plant; the Carnegie Steel Co.'s shapes are similarly given in an appendix. A list of sizes and properties of Z-bar columns is also given; it is gratifying to note that the Carnegie constant-dimension Z-bar column is not referred to. However, there appears to be no good reason why lists of standard columns of other make-up are not given, for instance, standard angle columns, lattice or plate, standard channel columns, lattice or box, etc. In building work even more than in bridge work a standardization of such columns should prove of great value.

Next follows a table of rivet values, and a diagram of conventional signs for riveting. This latter, unfortunately, is not the Osborne system, which we imagine is almost universally in use in this country, but follows that given in the Pencoyd hand-book, a system which appeals to us as less rational than the Osborne system and hardly likely to displace the latter. A number of tables follow giving data relating to sizes, weights and spacing of rivets and bolts, data on pins and pin-nuts, eye-bar heads, upset bars, clevises, sleeve-nuts and turn-buckles, looprods, buckle-plate and trough flooring, tubes, screws and nails, etc., all about as given in most of the structural hand-books. Page 38 is headed "Mensuration," and gives merely some formulas for irregular quadrilaterals and for circular segments. Quite aside from matter which would ordinarily be given in any hand-book under the heading "Mensuration," one might reasonably expect to find in this book a summary of the formulas for calculating "crooked" work, as skewbridges or hips and valleys; none of this matter, however, appears to be given.

Next are given tables of ordinates to 16-ft. chords, of bevels, of natural tangents, of multiple rivet spacing, of decimal parts of a foot, and (apparently quite out of its place) a table of maximum sizes of plates rolled by the Carnegie Steel Co. Nine pages are then devoted to reproductions of forms of titles to drawings, forms of erection plans, column schedules, and beam sheets.

The succeeding 12 pages are plates of standard details of corrugated steel work, gutters, flashing, louvres, opening devices, doors and windows and framing, etc. In connection with eight pages of text on the subject, this portion of the book appears to be thorough and well worked out. The same may be said of the remaining 18 pages, entitled "Rules for Making Shop Drawings," which constitute a very complete specification on the making of shop drawings for steel work. These last two sections are without doubt the best portions of the book.

Throughout the book practically nothing is presented that would bear out the title, "Standards for Structural Details." It is, of course, not possible to draw up a system of uniform details for steel work that shall be generally applicable; but a vast amount of work—vast in value and importance rather than in extent—might have been done in formulating general standards for guidance. This is true in bridge as well as in building work, both of which this volume pretends to cover: connections in steel work are yet detailed in so many ways, some excellent and some very bad, even by first-class engineers, as well as in the drafting rooms of the best shops in the country.

The announcement in the preface that the volume contains also tables and information for use in designing steel work is borne out even less than the title itself. Of the many diagrams, tabulations, lists of information and notes of different kinds which the designer of steel work finds necessary to properly facilitate his work, there is no trace in the book (a few blank leaves in the back are possibly put in for the recording of some such items). There is, for instance, not even a remark as to the permissible safe stresses which should govern designing of structural work in the engineering offices of the American Bridge Co.

As to the make-up of the book, not much can be said. The cuts, diagrams and tables, apparently all made from wax-process plates, are rather unsatisfactory. As a matter of detail, it may be noted that most of the drawings shown are shade-lined, while the best practice in detailing steel work, we believe, uses no shade lines in shop drawings.

It is to be hoped that when the volume before us is revised, some of the deficiencies we have attempted to point out may be supplied. It is highly desirable, moreover, that a compilation of the importance of this one should be circulated rather freely among engineers connected with steel construction; a more rapid standardization of practice in designing and detailing throughout the country might then be anticipated.

INTERMITTENT FILTRATION OF SEWAGE AT BROCKTON, MASS., DURING 1901.

We have often commented on the sewage disposal works at Brockton, Mass., as being one of the very few plants of the kind in the country which is under scientific control.* The last annual report of Mr. Chas. R. Felton, City Engineer of Brockton, contains a review of the operations of the filter beds for the year 1901, prepared by Mr. Geo. E. Bolling, chemist in charge.

Mr. Bolling states that after having been in operation for seven years the plant is as capable as ever "of purifying sewage to the high standard set" when it was first put in operation. This is all the more notable in view of the steady increase in the work put upon the beds. Taking into account the increase in both the quantity and strength of the sewage, the latter, as indicated by the albuminoid ammonia, the work accomplished has progressed as follows: 1896, 1; 1897, 1.6; 1898, 2.3; 1899, 2.9; 1900, 3.5; 1901, 5.0.

The combined amount of sewage and sludge pumped to the beds varied from an average of 1,388,570 gallons a day in April to 537,600 in September. For the whole year 1901 the combined quantity averaged 788,930 gallons a day, of which 703,730 was sewage and 85,200 gallons sludge (from the receiving reservoir at the pumping station). The temperature of the air ranged from 24° F. in January, to 77° in July. The temperature of the sewage at the beds ranged from 43.8° F. in February to 62.3 in September, and of the effluent from 43.3 in April to 64.0 in both August and September. For the whole year the average temperature of the sewage at the beds was 52.9°, and of the effluent, 53.5° F.

The strength of the sewage and sludge mixed (as calculated) showed an average for the whole year of 1.445 parts per 100,000 of albuminoid ammonia, of which 0.5758 was dissolved and 0.8692 suspended; oxygen consumed, 10.03, filtered, and 16.57, unfiltered; chlorine, 9.83. The range of chlorine was from 15.78 for August to 5.62 for

*For descriptions of this plant and its operations see Engineering News for Oct. 5, 1893; May 2 and 23, 1895; Feb. 27, 1896; May 20, 1897; March 29, and Sept. 13, 1900.

April. Analyses of samples of water from above and below the points where the effluent discharges into the Coweeset River continue to show an improvement in the river after it receives the effluent from the filter beds. Analyses of the effluent from the two main underdrains show a reduction of 96.7% of free ammonia, and 98.1% of both albuminoid ammonia and oxygen consumed from one underdrain, and 97.7, 98.8 and 99%, respectively, from the other.

The labor cost of operating the filter beds during the year 1901, including minor repairs, was distributed as follows: Maintaining the surface, $1,785; tending gates, $301; watchman, $68; samples, for analysis, $31; snow, $4; banks and roads, $58; lawn, $30; carriers, $43; gate chamber covers, $16; swamp, $95; miscellaneous, $247; total, $2,678.

The total quantity of sewage and sludge treated at the beds was 287,960,970 gallons for the year, thus making an average cost, for labor at the beds alone, of $9.30 per 1,000,000 gallons.

The sludge beds were raked, on the average, once for every 17 doses. A total of 1,405.5 tons of sludge were removed during the year and sold to farmers, as fertilizer, for $150. Three acres of yellow corn, raised on the beds, were sold standing for $26 per acre, against $10.88 per acre for planting the corn and removing the stubble. An acre of mammoth Russian sunflowers yielded about 33 bushels of seeds, which was sold at a slight profit. This crop was raised on a sludge bed, which was too strong for the best results.

PROPOSED LIGHT REFUSE CREMATORY FOR NEW YORK CITY.

A raffle incinerator, or in more common language, a light refuse crematory, is to be built by the New York Department of Street Cleaning on one of the piers used to load the sea dumping scows of the department. The primary object of this plant is to demonstrate the great saving in final disposal which may be effected by excluding from the dumping scows such bulky material as waste paper, excelsior, and packing boxes, thus leaving comparatively little but ashes and street sweepings to be towed to sea, or to bulkheads where they are used for filling. Contract prices for towing all the material, except garbage, collected by the Street Cleaning Department are on the yardage basis, and a large percentage of the yardage material is composed of the class of wastes which it is proposed to burn in the light refuse crematory. The secondary object of the crematory is to show that the material thus excluded may be burned within the city limits, in fact wherever a factory chimney would be tolerated, without nuisance, or even annoyance, to any one. Incidentally, but of great importance, the furnace will indicate the amount of utilizable heat in the class of refuse which it is designed to consume.

The accompanying illustrations show the style of furnace to be employed and how both it and its 114-ft. steel chimney stack are to be supported on the wooden dock, or pier, at the foot of W. 47th St. Fig. 1 is a general plan and elevation of the furnace. Fig. 2 shows its design in detail. Fig. 3 illustrates the method of anchoring the stack to the pier. It may be explained, first of all, that the carts containing light refuse, instead of passing along the dock, as formerly, and dumping over a rail onto scows, will pass up a ramp and dump into the storage hoppers shown in Figs. 1 and 2. From these hoppers the refuse will be passed through counterbalanced doors onto a ledge, and from here it will be pushed onto the inclined drying table, back of the grates. The partly-dried and heated material will next be pushed or raked forward onto the fires. There are three burning cells, each with a grate 5 × 6 ft. in plan. Fresh material is dumped on one grate at a time, so the gases of combustion from such a grate are mingled with those from the hotter fires. After these gases have passed the length of the three grates, which latter are separated by bridge walls, they pass over a third and higher bridge wall and return, at a lower level, back of the cells and beneath the drying table. They may then be sent directly to the stack, or beneath one or both of the vertical boilers near the stack. To retain any partly-burned paper that escapes from the furnace, checker work is built across the horizontal flue just beyond the cells, and a little further along an obstruction to dust is formed by raising the bottom of this horizontal flue.

The following details regarding the proposed plant have been abstracted from the specifications: The furnace will rest on a concrete foundation, placed directly on the flooring of the dock, but beneath the furnace section of the horizontal flue a fireproof floor of hollow tile will be placed, as shown in one of the longitudinal sections, Fig. 2. The concrete will be 4:2:1, with Rosendale cement. The brick work of the furnace will be braced and tied with cast-iron buck stays and steel tie-rods. The latter will be 1⅝ ins. in diameter, and where they pass through the brick work above the grate level they will be encased in 1½-in. lap-welded gas pipe.

The inside of the cells and flues, from a point about 12 ins. below the top of the grates, and including the underside of the roof arch, will be lined with A No. 1 fire brick, laid in ground fire clay. The tops of the bridge walls will be covered with special fire brick about 9 ins. thick. The drying tables and the bottom of the flue will be paved with fire brick.

The grate bars will be of wrought iron, 3 ins. deep, beveled to a taper cross-section ½-in. t... at the top and 3-16-in. at the bottom, with t... distance pieces of inverted taper. Every t... bars will be riveted together at the center ... ends.

The self-supporting steel chimney stack, Fig... will be not less than 114 ft. high, bolted to a c...

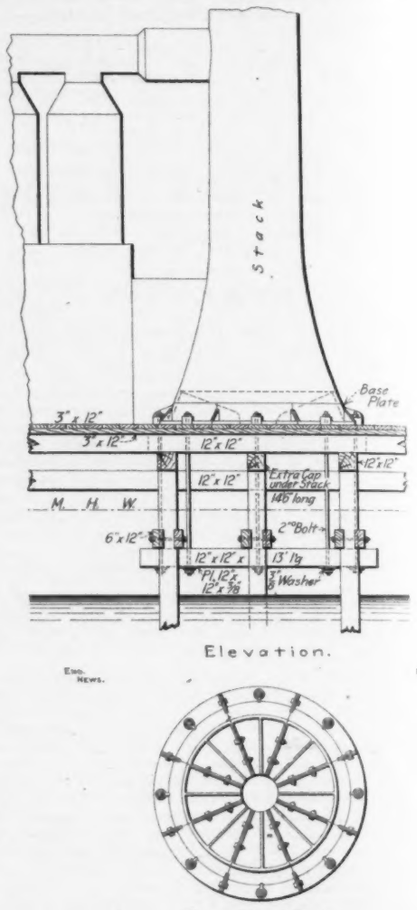


Fig. 3. Method of Anchoring Steel Chimney Stack to Pier.

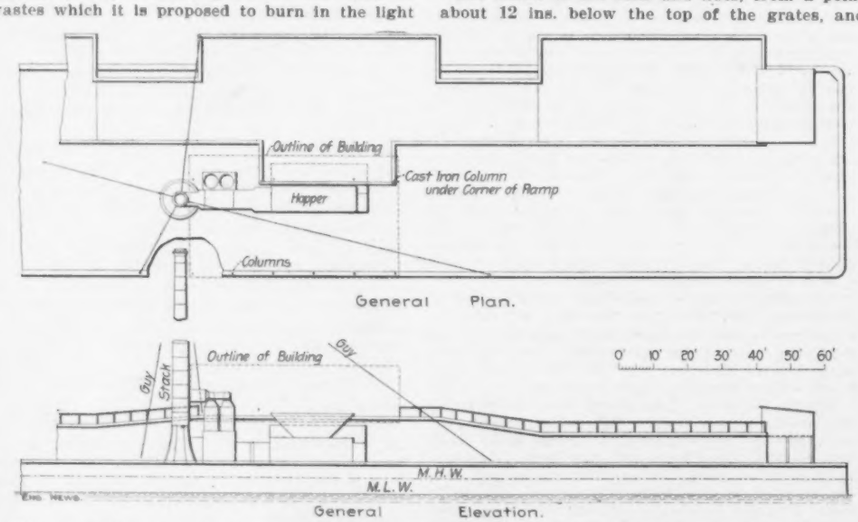


FIG. 1. GENERAL PLAN AND ELEVATION OF PROPOSED LIGHT REFUSE CREMATORY ON DUMPING PIER FOR NEW YORK CITY.

Dr. John M. Woodbury, Commissioner of Street Cleaning. H. de B. Parsons, M. Am. Soc. C. E., M. Am. Soc. M. E., Consulting Engineer.

iron base, and having extra supports of yellow pine timber and extra piles beneath it. The steel shell will be lined with fire brick, carried up until the lining has diminished to a thickness of about 4 ins. The inside diameter of the flue will be 3¼ ft. The steel plates composing the shell will be ¼-in. thick at the top, then 5-16, ⅜, and 7-16-in., in successive sections. Single riveting will be used down to one course above the flue opening, then double riveting. The steel shell will be painted inside and out with one coat of red lead before it leaves the shop. After erection, it will be given two coats outside, and one inside, of paint equal to "Protectus" or "Bitumastic."

The two 50-HP. (?) boilers will be 50 ins. in diameter and 84 ins. high, and will have 3-in. tubes capable of withstanding a pressure of 100 lbs. per sq. in.

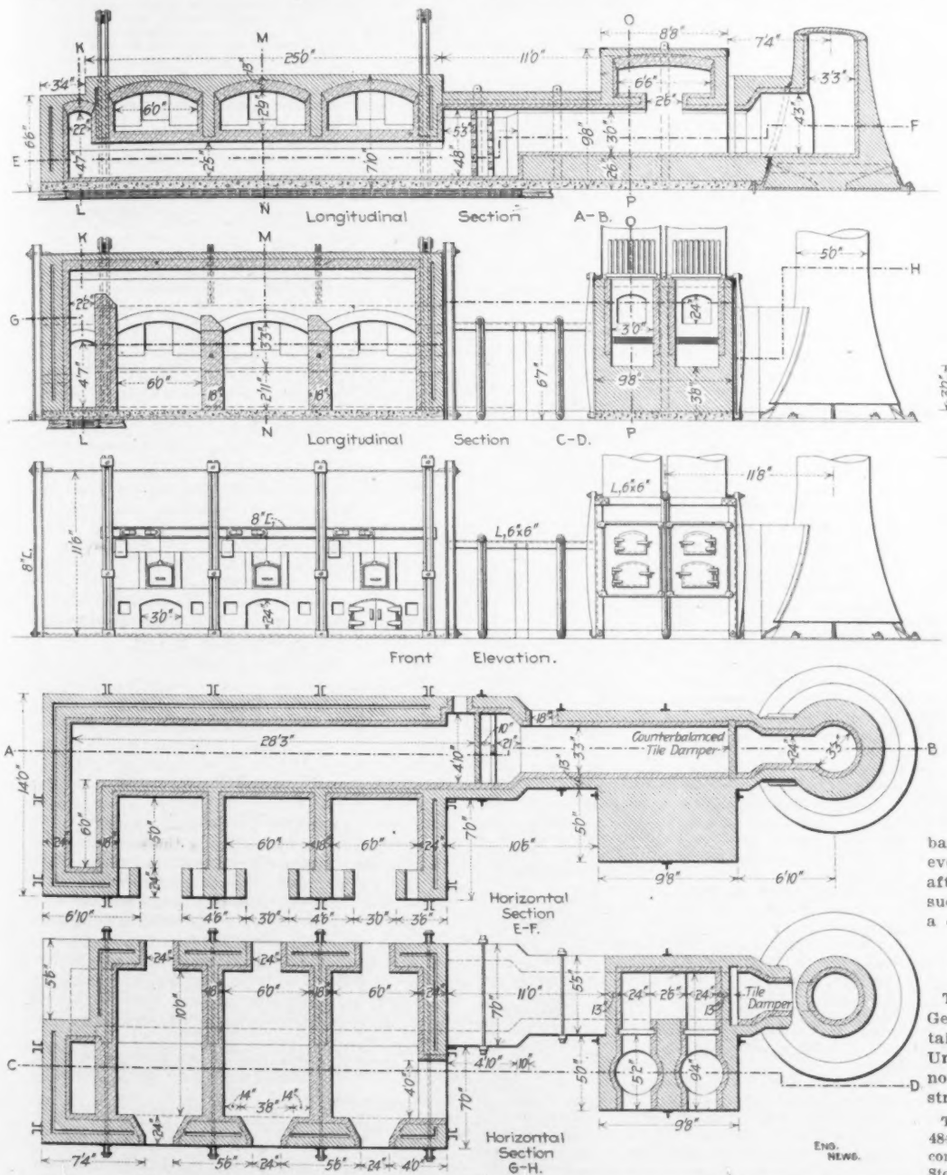
Steam pipes will lead from the boilers along the front of the furnace, with branches to spiders carrying two improved annular steam jets. The jets will be located in the ash pits. The jets will be used to supply forced draft, and the boilers, in addition, may supply steam for power, if desired.

The plant, as described, was designed by Mr. H. de B. Parsons, M. Am. Soc. C. E., M. Am. Soc. M. E., Consulting Engineer, 22 William St., New York city. Mr. John G. Woodbury, M. D., is Commissioner of Street Cleaning. We are indebted to both these gentlemen for courtesies extended during the preparation of this article, and to Mr. Parsons for blue prints and specifications.

While the plant is on a full-sized working scale, it is, nevertheless, considered by the department as experimental, or at least as a trial plant designed to determine the application of well-known and established principles to local conditions.

Refuse destructors, as they are called, are common enough abroad, and there are plenty of garbage furnaces in this country, but each burns more miscellaneous material than is contemplated in this case. The English refuse destructors receive, in addition to light refuse, large quantities of ashes and more or less green garbage, while very few of our American cities send ashes to their garbage furnaces, and most of them probably send there more kitchen garbage and market refuse than anything else. The proposed plant also differs from the two refuse furnaces previously tried in New York,* and the one now used in Boston, in that the three plants just named burned only the tailings, as they might be called, from refuse sorting and utilization plants. That is, the light refuse carts in New York formerly brought, and in Boston still bring, their loads to a sorting station. The material is there thrown onto inclined conveyors, and men and boys pick out the various grades of paper, rags, and other merchantable material, leaving the worthless stuff to be tipped off the upper end of the conveyor into the furnace. Sorting to the same end, but in a different manner, is practiced on the New York dumping scows under the name of "trimming the scows." That is, the material is overhauled as it is dumped load by load on the scows. The trimming privilege brings, or has brought, the city a revenue of many thousand dollars. The plan of the late Colonel Waring was to collect the paper and other light refuse separately, and never have it mixed with the ashes and street sweepings. The salable portions could then be recovered, as described. Under the plan now to be tested, as we understand it, the light refuse will still be collected separately, but all of it will be burned. It is thought that this will be more sanitary than to have the wastes overhauled, and portions of them, regardless of their possible infectious character, utilized in various manufactured goods. Unquestionably, the sanitary phases of the problem should be placed first, but in a city having a well-organized board of health, and having its light refuse collected separately, the possible menace to health resulting from sorting and utilizing light refuse is an ill-defined and not easily determined quantity. It is well worth while, however, to see just what burning all the light refuse will cost, and to what extent, if any, the expense may be offset by the utilization of heat. Some data, though meager, are available on the expense and revenue incident to refuse sorting and utilization plants. The cost of dumping at sea, as well as the revenue from trimming the scows, is also pretty well known.

Certainly the New York Street Cleaning Department is to be commended for installing a trial plant of its own, designed by a competent engineer. If we mistake not, this will be the first time that an American city has employed an engineer for such a purpose. Somewhere from 70 to 100 municipalities in the United States have garbage furnaces, but, so far as we are informed, every one of them has been built by contract, after the contractors' plans. Rarely, indeed, have such plans been subject to the approval, even, of a competent engineer, employed by the city.



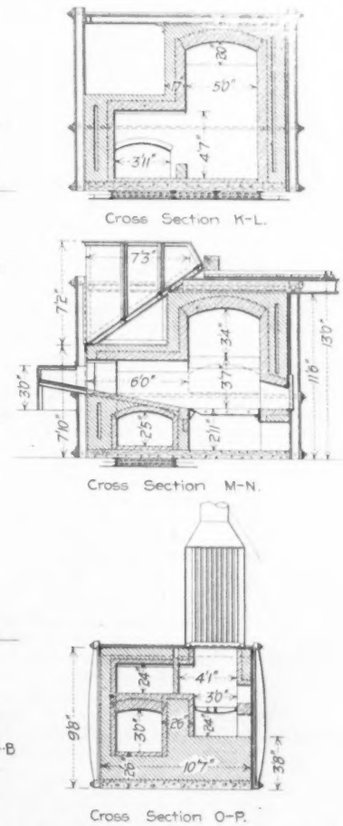


FIG. 2. DETAILED SECTIONS AND ELEVATION OF PROPOSED LIGHT REFUSE CREMATORY FOR NEW YORK CITY.

*One of these, the Colwell, was described in Engineering News of Nov. 21, 1895. A later one was constructed during the time the late Colonel Waring was in charge of the Street Cleaning Department.

THE COAL FIELDS OF THE UNITED STATES.

The third part of the 22nd Report of the U. S. Geological Survey, now in press, is devoted to detailed reports upon the various coal fields of the United States; several of these have been briefly noted in recent issues of Engineering News. Abstracts of others follow:

The Pennsylvania anthracite fields underlay in all 484 sq. miles; though these workable measures are not continuous, consisting of detached basins. Mr. H. H. Stoek estimates that these measures contained 19,500 million tons of coal before mining began; and Mr. D. A. Smith believes that this vast amount of coal only represents 6%—or even 1%—of the original coal deposit, before erosion commenced to remove or redistribute it. The production of anthracite coal, in decennial periods, is thus set down: 1880, 28,700,000 tons, valued at $42,300,000; 1890, 46,500,000 tons, valued at $66,400,000; 1900, 57,400,000 tons, valued at $86,000,000. The capital invested in anthracite coal mining in Pennsylvania amounts to about $700,000,000, and in 1899, 140,656 people were engaged in this industry.

Anthracite coal was discovered in the Wyoming Valley

in 1762; in 1769 Obediah Gore used anthracite coal in his blacksmith's forge; in 1802 it was burned in a grate in Philadelphia, and in 1812 it was successfully used in an iron furnace at Philadelphia. Coal was shipped to Boston, around Cape Cod, as early as 1823; and the period 1820-40 covers the canal exploitation of this coal; railway transport officially beginning in the latter year. The cost of mining this coal is set down at about $1.50 per ton; but late improvements in machinery and concentration of interests have increased the average daily breaker output from 500 tons in 1887, to 880 tons in 1897. The selling price of prepared coal at tidewater, per ton, is noted as follows: 1877, $3.26; 1887, $3.67; 1897, $3.46.

The Southern Appalachian coal field, says Dr. C. W. Hayes, commences in the southern row of counties in Kentucky and includes parts of the states of Tennessee, Georgia and Alabama, the belt being from 30 to 85 miles wide. Coal was discovered in this field by the early settlers, and some coal was mined in Alabama in 1836. This coal is all bituminous, and the large proportion of it produces coke about equal to that of the Connellsville standard. The actual development of these coal fields began in 1854 with the building of railways. The Roane Iron Co.'s furnaces, at Rockwood, Tenn., built in 1867, demonstrated the use of this coal for coking and marks the beginning of the greater development. Omitting the three Kentucky counties, the product of this field was over 973,000 tons in 1880, valued at over $1,338,000; 6,488,000 tons in 1890, worth $6,800,000, and over 12,418,000 tons in 1900, valued at over $14,300,000. Of this product 27% was used for railway fuel; 36% for manufacturing fuel; 14% for domestic fuel, and 23% in making coke.

The Western interior coal field lies within the prairie lands of the Mississippi Valley, in Missouri, Kansas, Iowa and Nebraska, with a total area of about 66,000 square miles. The probable production area is about 39,000 square miles, but the coal of this field is very irregular in distribution, the beds varying from 18 ins. to 6 ft. thick; in exceptional pockets coal formations 70 ft. thick have been found. These coals are exclusively bituminous and essentially steam coals, but owing to the irregular distribution it is impossible to give any trustworthy estimate of the probable total yield. As to annual product, in 1900, 564 commercial mines in Iowa, Missouri and Kansas produced a little over 13,200,000 short tons, valued at the mines at about $16,900,000. Of this output 33% was used for railway fuel, 25% for manufacturing fuel and 42% as domestic fuel.

The Southwestern coal field lies in the Indian Territory, Arkansas and North Texas, the first named deposit being directly connected with those of Kansas and Arkansas. The whole field has an area approximating 20,000 square miles. The coal deposits vary in character from a high-grade and good coking bituminous coal to semi-bituminous and semi-anthracite coal. In 1900 this field produced 3,906,275 tons, valued at $5,424,558, and of this generally 43% was used by the railways, 23% for manufacturing and 32% for domestic fuel. As shipment of this coal is entirely by railways, the development of the field has depended entirely on railway building.

THE DECISION IN THE DAYTON ELECTROLYSIS SUIT.

A partial victory has been won by the city of Dayton, O., in its electrolysis suit against the City Railway Co. Mr. O. B. Brown, Judge of the Court of Common Pleas of Montgomery Co., has refused to order the street railway company to install the double trolley system, as urged by the city, but says the company has been negligent in the operation of its road and must conform to the best standard practice of operating single trolley lines.

The trial was a lengthy one, the experts were numerous, and there were many exhibits and several experiments before the court. The decision of Judge Brown occupies two full pages of the Dayton "Herald" for April 5, 1902. A large part of the opinion deals with purely local questions, and the findings of the court hinge largely upon the nature of the franchise granted by the city to the street railway company. The decision, therefore, has only a general bearing upon the electrolysis question in other cities, and, it is to be remembered, is subject to review in the higher courts.

After a detailed review of the contentions of the city and the company, and of the law on the subject, the Judge concludes that a contract existed between the city and company "for the construction, operation and maintenance of a single trolley electric railroad."

Another point made by the Judge was that the city had never attempted to compel a change in the method of traction by the exercise of its police powers, and that the court had no authority to exercise such power. For this and other reasons the Judge held that even if the facts showed that the double trolley or the underground conduit system was the only method of preventing the destruction of the water mains by electrolysis, yet the law would not permit him to order the adoption of one or the other mode of traction.

The first trolley line in Dayton was installed in August, 1888, "but the present system of operation did not become general until the early nineties." This first line, it appears, was owned by a company other than the defendant in this suit, and the first noted instance of electrolysis was upon a lead service pipe, near this same early line, found in 1893. That same year, Mr. Chas. E. Rowe, Secretary of the Dayton water-works, was sent to the Milwaukee meeting of the American Water-Works Association, where, the Judge says, "the question of the electrolysis of water pipes was first publicly discussed."

Both sides to the suit admitted that the water pipes of Dayton are being damaged by electrolysis, but they did not agree as to the extent of the damage. During the trial a 6-in. water main broke, when, in the course of a fire, the pressure was raised from 60 to 100 lbs. The broken pipe was, the Judge says,

brought into court the following morning and examined by the experts for the first time in court. This showed that the pipe had been badly eaten away throughout its entire length by electrolysis, and indicated to the experts that the current was pretty uniformly distributed over the surface.

Rivers, canals, steam railways and intersecting street railway lines, the Judge says, conspire to make the return of the electric current to the power house unusually difficult in Dayton.

All the experts in the case testified that the defendant had operated its railway "in a very inefficient and negligent manner, and far below the present standard of the art." The bonding is very inadequate throughout. In fact, a chart introduced by the defendant raises "a doubt as to there being any good bonds on most of the system." The experts also agreed that the system of return feeders in use "is not sufficient for the economical and safe operation of the" railway. The ground plates in use are no longer considered good engineering.

The balance of the opinion, with the summary of findings, is given substantially in full, as follows:

The testimony in this case shows that the plaintiff is powerless to adopt any method whatever to protect its piping system. On the other hand, a single trolley street railroad, such as the defendant operates, can adopt no method by which the tendency of the current to flow through the earth and on to the pipes can be entirely overcome. But I am of the opinion that by co-operation between the two, such a system could be adopted as would reduce the injury resulting from electrolysis to a minimum or negligible quantity as the experts term it.

The defendant claims, however, that no system would prove effective as long as the other roads continue to operate as they are, but the testimony shows that any preventative measure adopted by this company would reduce the liability to injury to that extent.

The rails should all be metallically connected by adequate bonding, and the bonding well inspected frequently, and heavy copper cables should be used to conduct the current across the bridges and under the steam railroad crossings and intersecting railroad tracks. Return feeders of sufficient conductivity should connect the rails at various points to the negative bus-bar of the dynamo. This would increase the conductivity of the rail path and induce a much greater quantity of the current to flow thereon.

The ground plates which are still in use by the defendant should be removed, thus reducing the tendency of the current to flow to the underground metallic structures.

Having corrected the system by proper bonding, and by proper rail return, there should be co-operation on the part of the water-works board in permitting to be placed, as may be determined, at the proper places, the necessary insulators in the piping system. A few or none may be required.

A system operated along these lines without insulators or pipe connections to the rails or dynamo, has proven successful in Hartford, Conn., and in other cities, where the conditions are somewhat similar to those existing in this city.

The officials of the city of Chicago have also acted upon this theory, and have passed an ordinance making it unlawful for

any person, firm or corporation, owning, operating or controlling any surface or elevated railroad or any street railway within the city of Chicago, upon which cars are now or hereafter operated, by electricity as a motive power with a grounded return circuit for conveying electricity to operate their system without a

metallic return circuit of such cross-section and conductivity for conveying the current so used as a motive power that the maximum difference of potential will not at any time exceed one volt between any part of such metallic return circuit and any water pipes, gas pipes, or other metals not installed for the purpose of forming a part of such metallic return circuit, and that there will not be a variation in difference of potential, exceeding one-half volt, between any two measurements made at the same time at points along and upon said metallic return circuit within a distance of 300 ft. or less from each other.

Similar regulations have been made in other cities in this country, and general regulations have been adopted by the different British boards of trade and by what is known as the Bristol Tramways Act, and it is now generally considered by practical and scientific men that if a difference of potential not higher than about 1½ volts is maintained in the positive district, and difference of potential not higher than about four volts in the negative district, the pipes will be practically immune from damage.

I am satisfied, from a careful consideration of all the testimony, that if these remedies are applied with intelligence, according to the present state of the art, it is possible to establish and maintain, by careful and frequent inspections and electrical measurements, such a return for the current of the City Railway Co., as will practically protect the water pipes of the city, and be also a great saving to the railway company in the cost of operation.

SUMMARY OF FINDINGS.

Upon consideration of the entire matter I have come to the following summary of conclusions as to the law and facts:

This court has no authority in law to compel a change in the system from the single trolley to the double trolley, and, if the same was warranted by the law, the facts would not justify such a change.

The defendant has been and is operating its road in a negligent manner, causing continual damage to the water pipes of the plaintiff, for which the plaintiff has no adequate remedy at law, and cannot by any practical method prevent such damage.

It is no excuse in law, and the facts would not justify the defense that other electric lines in Dayton are contributing to this or doing like damage. (Spelling, Secs. 396-397. McClung vs. North Bend Coke Co., 9, C. C. 230; Meigs vs. Lister, 23 N. J. Eq. 199.)

It is therefore the duty of the court to enjoin the defendant from so operating its railway and to compel it within a reasonable time, to introduce such improvements in the system, in order that the operation of the single trolley system authorized by the franchise and contract, will be in accordance with the present standard of the art of operating single trolley roads. The plaintiff shall cooperate to that end.

All matters of detail can be arranged between counsel and the court in the final order.

The costs will be adjudged against the defendant.

After the foregoing decision was rendered, counsel for the railway company addressed some remarks to the court, in which it was virtually stated that if the city would let the case stand, without appeal, it would do the same, and, of course, would also comply with the orders just given.

A SIMPLE METHOD OF CALCULATING CONTINUOUS AND CONSTRAINED BEAMS.

By Edward Godfrey.*

The calculation of reactions and moments in continuous girders involves the solution of one or more equations formed in accordance with the general formula, called the "Theorem of Three Moments." The operation of substituting values in this formula and solving the resulting equations is entirely mechanical, and this fact, in connection with the complexity of the formula, makes the finding of the desired quantities a long and tedious matter, and one much liable to error.

The three-moment formula may be much simplified and reduced to an easily-remembered rule, in such a way as to make the application simple and easy, not only to the case of continuous girders, but also to fixed-end or other constrained beams. Moreover, the formula is practically reduced to one form for both concentrated and distributed loads, in place of the two well-known three-moment formulas.

The common expression of the theorem of three moments for concentrated loads in each of two adjacent spans is,

$$M_{r-1}\, l_{r-1} + 2\, M_r\, (l_{r-1} + l_r) + M_{r+1}\, l_r =$$
$$-\, l^3_{r-1} \sum P_{r-1}\, (k - k^3) - l^3_r \sum P_r\, (2\,k - 3\,k^2 + k^3)$$

where the symbols represent quantities as shown in Fig. 1, and, for any one load, $k = \frac{a}{l}$. The relation expressed involves (1) that the moment of inertia be constant in the length,

$$l_{r-1} + l_r,$$

and (2), that the supports fit the natural unstressed form of the beam, i. e., all reactions must reduce to zero at the same instant.

*Instructor in Mathematics and Graphics, Western University of Pennsylvania, Allegheny, Pa.

Let us now measure a in the second span to the left, toward the center support. This changes k to 1 — k, and makes the second term of the right-hand side

$$l^2, \Sigma P_r (k - k^2),$$

which is identical in form with the first term of that side of the equation. We may now restrict our attention to a load on one span only, remembering that the same results will hold for a load on the other span, provided a is always measured toward the center support of the three supports considered.

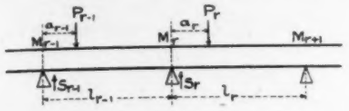


Fig. 1.

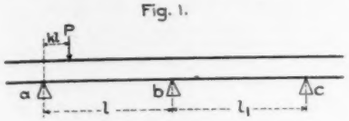


Fig. 2.

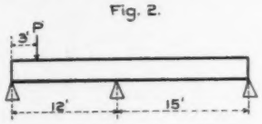


Fig. 3.

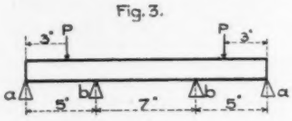


Fig. 4.

For one load on the left-hand span, Fig. 2, we have

$$M_a l + 2 M_b (l + l_1) + M_c l_1 = - P k^2 (k - k^2)$$
$$= - P k l (1 - k) (1 + k) l.$$

In the latter expression we note that

$$P k l (1 - k)$$

is equal to the moment under the load if that span were a simple beam. Now, expressing the formula as a rule, we get,

Left-hand side	Moment at left support times left span-length, plus twice moment at center support times the sum of the two spans, plus moment at right support times right span-length,
equals	equals
Right-hand side	"simple beam moment" under load, increased by the fraction k of itself, times the corresponding span-length.

If there is a uniform load of w per unit on one of the spans, it may be considered made up of concentrations w l dk; substituting this for P in the above equation, we get w l^3 (k — k^3) dk, and integrating between k = 0 and k = 1, we get,

$$\frac{w l^3}{4} = 2 l \frac{w l^2}{8}.$$

Or, putting it into the form of a rule, in case of uniform load on one span, the right-hand side of the moment equation is double the "simple beam moment" at center of span times length of span. The left-hand side of the equation is the same as before.

If there are no loads between the supports in question, the right-hand side of the equation becomes zero.

APPLICATION OF RULE ILLUSTRATED.

1.—Given the case of a beam continuous over three supports with quantities as in Fig. 3, to find the moment over the center support.

The bending moment in the first span, considered as a simple beam, is

$$\frac{P}{4} \times 9 = 2\tfrac{1}{4} P \text{ ft. lbs.}$$

Increasing this by one-quarter gives $\frac{45}{16}$ P. This times the span is $\frac{135}{4}$ P. Minus this moment will then be equal to the moment at the first support times 12, plus two times the moment at the middle support times 27, plus the moment at the third support times 15. But the moments at the end supports are zero. Hence we have

$$54 M_b = - \frac{135}{4} P \text{ or } M_b = - \frac{5}{8} P.$$

2.—As another example, and one that could often be made use of when calculating the moment on a pin over four supports, as in the case of a shoe with four webs, let us take the problem of Fig. 4. This being symmetrical the moments over the two middle supports are equal. As before, the moments at the end supports are zero. Then we have

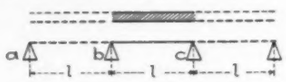


Fig. 5.

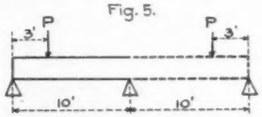


Fig. 6.

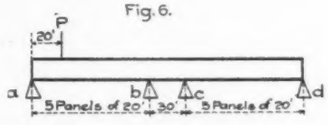


Fig. 7.

$$- P \times \frac{3}{5} \times 2 \times \frac{8}{5} \times 5 = 2 M_b \times 12 + M_b \times 7;$$

or,
$$M_b = - \frac{48}{155} P.$$

3.—Again, take the case of a fixed-ended beam uniformly loaded with w per unit, as in Fig. 5. We can consider this as one in a series of an infinite number of equal spans, similarly loaded. The loads in the spans a b and b c affect the relation between the moments at these three supports. The moment as a simple beam in the span a b, as we have found, would be doubled. The same moment in the span b c would also be doubled. Then, remembering that the moments at a, b, and c are equal, we have

$$- \frac{w l^2}{2} \times l = M_b (l + 4 l + l);$$

or,
$$M_b = - \frac{w l^2}{12}.$$

4.—For a beam fixed at one end and supported at the other, we can imagine another span, as in Fig. 6, to make the beam level at its middle support. Applying the rule here we have

$$20 \times 2 M_b = - P \times \frac{3}{10} \times 7 \times \frac{13}{10} \times 10 \times 2$$

$$\therefore M_b = - \frac{273}{200} P \text{ ft. lbs.}$$

If the load is uniform in the last example, the rule shows that four times the moment at b equals four times that in the span as a simple beam, or that the moment at b is $\frac{w l^2}{8}$.

5.—The reactions for drawbridges are very simply found by this rule. For the moment due to a panel load P, in Fig. 7, we have

$$2 M_b \times 130 + M_c \times 30 = - \frac{1}{5} P \times 80 \times \frac{6}{5} \times 100$$

and
$$M_b \times 30 + 2 M_c \times 130 = 0.$$

The solution of these two equations will give the moments at the supports, and from them the reactions can be easily found. For example, the moment at c equals the reaction at d multiplied by the span 100. The moment at b equals the algebraic sum of the reaction at d times 130, and that at c times 30, etc.

Examples could be multipled, and in fact all of the ordinary cases of the continuous girder solved by the application of this simple rule.

The purpose in giving numerical examples is not to find formulas for the different cases, but to show how simply any case may be solved by the application of this rule instead of working in the dark by the mechanical application of a long and tedious formula. By this method the calculations for a continuous girder are rendered almost as simple as for a simple beam.

A LOCOMOTIVE FOR BURNING LIGNITE FUEL.

A locomotive specially designed for burning lignite has recently been built by the Baldwin Locomotive Works for the Bismarck, Washburn & Great Falls Ry., of North Dakota. The engine is a four-cylinder, Vauclain compound, with cylinders 14 × 26 and 24 × 26 ins.; it weighs 166,900 lbs., with 128,000 lbs. on the eight 50-in. drivers, 16,900 lbs. on the pony truck, and 22,000 lbs. on the 30-in. trailing wheels under the firebox.

The special feature of the engine is in its firebox, which is both wide and deep. At the bottom it is 8 ft. long and 7 ft. wide, but an inclined front water leg increases the length to 9 ft. 4 ins. at the tube plate. The depth is 5 ft. 7¼ ins. at the front and 5 ft. 4¼ ins. at the back. In cross-section, the crown sheet has a radius of 6 ft., with corners of 15 ins. radius, from which the side plates slope outward to the mud ring. There is a single fire door, 16½ × 35 ins., and rocking grate bars are used. The boiler is of the straight-top type, with a diameter of 5½ ft., and contains 270 tubes, 2 ins. diameter and 16½ ft. long. The grate area is 56 sq. ft., and the heating surface is 2,496 sq. ft., of which the tubes represent 2,322 sq. ft.

A straight smokestack is used, with an extension smokebox and the usual netting for arresting sparks. The screen first used was 3½ × 3½ ins., of rather finer mesh than that used for ordinary coal-burning locomotives, but this has been replaced by a screen of 4 × 4 ins., giving about ⅛-in. mesh. A special spark-arresting device is under consideration, should the screen prove insufficient, but this has not yet been determined as the engine has not been in service during the dry season. In speaking of this engine in an address before the New York Railroad Club, Mr. S. M. Vauclain, of the Baldwin Locomotive Works, made the following remarks: "Lignite is a free-burning fuel, very light and full of water, similar to green wood. Therefore, in addition to a very large grate surface, it is necessary to provide great depth of furnace."

Mr. E. H. Walker, Traffic Manager, informs us that while the lignite coal is found in deposits all over that section of North Dakota, there are exceptionally large quantities of it along the line of the Bismarck, Washburn & Great Falls Ry., the quality of which appears to be somewhat better than that found elsewhere in the State. The analysis of the lignite is about as follows:

Moisture	22.06%
Volatile combustible	42.72%
Fixed carbon	30.50%
Ash	4.72%
Heat units, by Parr calorimeter	11,073

The use of the lignite effects a great saving in cost of fuel, as it can be put on the engine at a price not exceeding $1 per ton, as compared with $6 per ton for eastern coal. At these prices the saving is about 50%. As the engine has only been in service a few weeks, the comparative cost for engine repairs is as yet undetermined, but as the coal burns very much the same as wood it is presumed that it will not be as severe on the firebox and tubes as is the eastern coal. A deep fire is carried, and when the full capacity of the engine is required, the fire is about level with the fire door. No trouble has been experienced with the exhaust lifting the fire under any conditions of working. There are several grades of 1%, one of them about two miles long, up which the engine easily takes its full tonnage loading.

The engine was built to haul a train load of 890 tons on a 1% grade with 9° curve, the atmospheric temperature being 55° F. In a test made when the temperature was about 30° F., and with a little snow on the rails, the engine hauled a

train load of 940 tons over this piece of track, maintaining a boiler pressure of 190 to 200 lbs. and using sand only where snow covered the rails. Two trial runs were also made in February on the Northern Pacific Ry. between Mandan and Jamestown, N. Dak., a distance of 107 miles, with grades averaging about 0.4%. The results of these tests, as given by Mr. Walker, are as follows:

	Eastbound.	Westbound.
Train load	1,288 tons.	1,564 tons.
No. of cars	42	45
Coal consumed*	36,000 lbs.	50,500 lbs.
Steam pressure, average	195.15 "	188.28 "
" " maximum.	200.00 "	200.00 "
" " minimum.	160.00 "	140.00 "
Water level in boiler, ave.	2.88 gages.	2.53 gages.
" " " " max.	3.00 "	3.00 "
" " " " min.	.50 "	.50 "
Cut-off on quadrant, ave.	2.5 notches.	4.5 notches.
" " " max.	9.0 "	10.0 "
" " " min.	1.0 "	1.0 "
Wat. evap. per lb. of coal.	2.4 lbs.	2.1 lbs.
Running time, inc. delays.	11 h. 30 mins.	15 h. 42 mins.
Excluding delays	3 h. 57 mins.	8 h. 2 mins.

*Including about 3 tons and 2½ tons, respectively, for firing up, etc.

ECONOMICAL POWER DEVELOPMENT WITH SUPERHEATED STEAM IN A DE LAVAL STEAM TURBINE.

The considerable economy in first cost and operation that may be reached with the use of superheated steam in engines is offset in a measure by certain difficulties connected with such use. These difficulties arise mainly from the lack of resistance to the higher steam temperatures of the various lubricating oils, packings and bearing metals that are used in different portions of the mechanism directly exposed to the action of the steam. Steam turbines present such obstacles to the use of superheated steam in very much smaller measure than do reciprocating engines, and it is, therefore, important to know the effect of superheating the steam on the efficiency of this class of power-generators.

A number of experiments in this direction have already been recorded. Very recently a series of such tests on a De Laval steam turbine has been carried out by Mr. A. Lewicki in the mechanical laboratory of the Technical College at Dresden, Germany. The results obtained, given in the "Zeitschrift des Vereins Deutscher Ingenieure," demonstrate quite thoroughly the increased efficiency reached by the use of superheated steam in machines of this type.

In steam turbines generally the entering steam does not come in contact with rubbing surfaces which require lubrication. In turbines of the De Laval type, utilizing the velocity of the steam jet, the moving parts (with the exception of valves) do not come into contact with steam at initial pressure and temperature at all, as during the flow of the steam from the nozzle a high degree of expansion and consequent temperature reduction takes place, the pressure being almost entirely converted into kinetic energy before the steam strikes the vanes of the rotating wheel. It might naturally be concluded from these facts that in machines of this class practically no limit is set by questions of successful engine operation to the initial temperature of the steam that may be used. The experiments have fully confirmed this conclusion: it was found that there was nothing in the way of operating the turbines at the highest temperatures that can be reached by superheating arrangements at present in use. In continuous operation the admission valves, the governing throttle and the needle valves controlling the nozzles, might give some trouble at the high temperatures; in the experiments of Mr. Lewicki the nozzles were made of steel, and no difficulties of this nature arose.

The results of the tests carried out by Mr. Lewicki are briefly summarized in the following table. Each value given is the average of an extended series of experiments, and may be taken to be free from accidental errors.

Table of Efficiencies of De Laval Steam Turbine.

Initial steam pressure, 103 lbs. abs.; speed of gear shaft, 2,000 revs. per min.; speed of turbine, 20,000 revs. per min.; turbine running non-condensing.

	Half load		Full load	
	Saturated steam	Superheated steam	Saturated steam	Superheated steam
Initial temperature of steam, °F.	327	860	327	932
Discharge temp. of steam, °F.	212	588	212	650
Brake horse-power	21.4	24.5	44.1	51.9
Stm consumptn, lbs. pr HP. hr	47.5	31.0	38.9	25.3
B.T.U. per HP. hour:				
Heat consumption	56,100	44,600	46,000	37,200
Residual superheat	...	5,610	...	5,310
Economy*	...	30%	...	31%

*Over saturated steam when residual superheat is recovered.

The table shows that superheating the steam decreases not only the steam consumption, but also the heat consumption per unit of power developed. The available power of the engine is at the same time considerably increased. These results are produced mainly by the greatly increased energy of the jet of steam at the higher temperature and velocity. A portion of the economy is, however, due to the decreased internal friction of the turbine when superheated steam is used.

This decrease in internal friction was demonstrated by a separate series of tests, the turbine being run at the same speed as before, i. e., 20,000 r. p. m., giving 2,000 r. p. m. at the gear shaft. When using saturated steam the total friction loss in the machine was 5.5 HP.; using superheated steam at 572° Fahr. the loss was only 4.2 HP. These figures include, besides the resistance to the wheel's rotation, the bearing friction (probably also the gear losses). Deducting the latter, the net wheel resistance is given as 3.3 HP. for the saturated steam and 1.9 HP. for the superheated steam; the engine exhausting against atmospheric pressure. When a vacuum of 19" of mercury was maintained, the net loss due to wheel resistance was only 1.5 HP. and 0.6 HP. respectively, for the two conditions of the steam.

THE NEW YORK RAPID TRANSIT RAILWAY.

VII.

Contract Sections I. and II.

As stated in a preceding article the New York Rapid Transit Railway was divided into 17 contract sections, each of which was placed in the hands of a subcontractor for actual construction. The subcontracts for Contract Sections I. and II. were let to the same firm, the Degnon-McLean Construction Co., of New York city. For this reason and also because the methods of work on the two sections are essentially similar they are described together. Mr. Francis D. Fisher, M. Am. Soc. C. E., is the engineer in charge of the work for the contractors. The route in detail is as follows: Starting from near the junction of Park Row and Broadway the road runs along Park Row to Center St., with a loop line for local trains under City Hall Park. Thence the route is along Center St., New Elm St., Elm St., and Lafayette Place to Great Jones St.

MATERIALS PENETRATED.—With the exception of the stretch between Pearl St. and Broome St., the soil encountered is a soft sandy loam with sand underneath, and can be excavated by shovels. From Pearl St. to Broome St., there was formerly a pond which was gradually filled with rubbish as the city grew northward. This made ground is somewhat uncertain, and as is stated further on, is likely to call for a special foundation construction.

DESCRIPTION OF STRUCTURE.—The first of the 17 contract sections into which the Rapid Transit Railway work was divided includes the City Hall Loop and Park Row spur tracks, and extends north to Chambers St. The map, Fig. 27, shows this section its full length. As will be seen, the regular parallel four-track construction begins just south of the Brooklyn Bridge station at the entrance to the Brooklyn Bridge. Here the four-track line is changed to a six-track line, four tracks of which continue south on the same level and parallel to each other to a point near the intersection of Park Row, Ann St. and Broadway, while two tracks form a loop passing under the

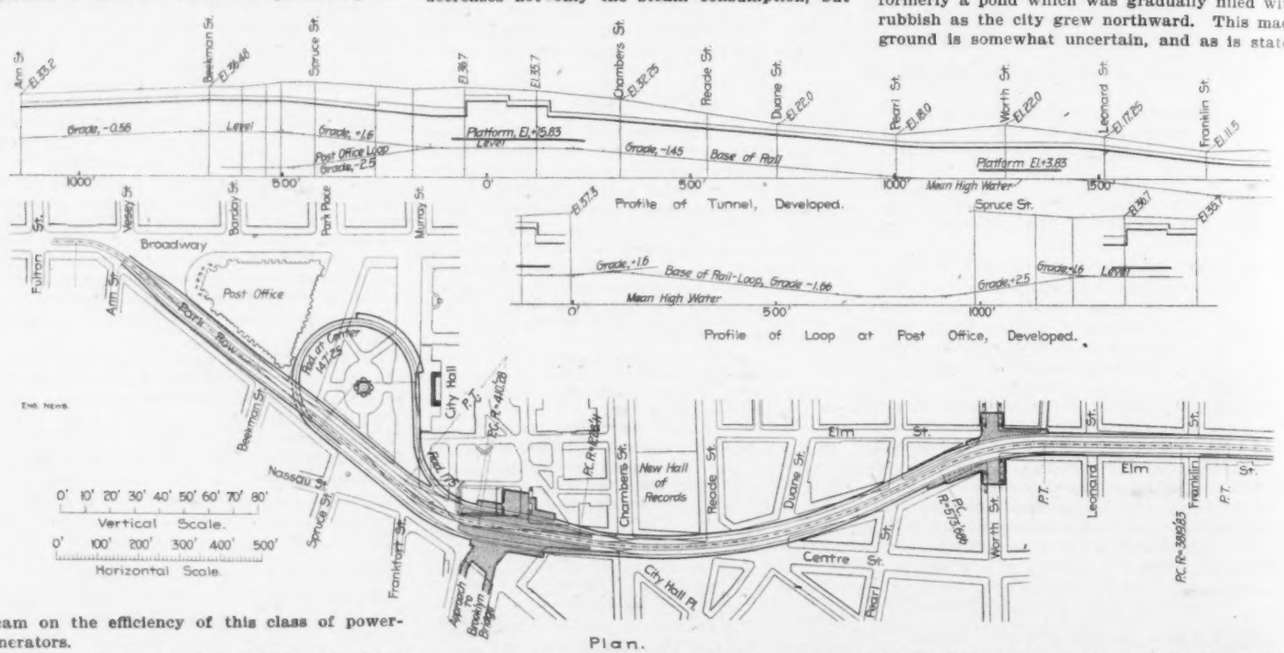


FIG. 27. MAP AND PROFILES OF CITY HALL LOOP AND ADJACENT SECTIONS OF RAPID TRANSIT RAILWAY.

Degnon-McLean Cons. Co., New York City, Contractors.

four-track spur and under City Hall Park. The arrangement of these several tracks and of the switches connecting them is clearly shown by the drawing.

When the road was first planned it was intended to have the standard parallel four-track line change at the Brooklyn Bridge station into a double-deck four-track line forming a loop around the post-office. The change from this plan to the present plan shown in Fig. 27 was inspired by the decision to continue at once the road down Broadway and under the East River to Brooklyn. This Brooklyn Extension will be a two-track line, and will begin at the end of the Park Row spur shown in Fig. 27. The present plan then is as follows: The two inside tracks at the Park Row station are express tracks and down-town express trains on the down-town inside track will undergo, in the four-track spur along Park Row, the necessary switching operations to transfer them to the up-town inside track. The two outside tracks at the Brooklyn Bridge station are local tracks and trains on the down-town local track will pass around the City Hall loop to the up-town local track. Fig. 27 shows the profiles of the Park Row spur and the City Hall loop.

The construction of the Park Row spur is the standard four-track subway construction described in a preceding article, and calls for no special mention. A special tunnel structure is used for the City Hall loop. This special structure begins just where the east outside track begins to swing under the four-track spur, and, except at the station, and immediately under the spur tracks, is of the form shown by Fig. 28. It is a rather heavy concrete structure with an interior width of 15 ft. and a height of 14 ft. 10 ins. The other dimensions and details are clearly shown by the drawing. At the station the standard tunnel section changes to a construction with vault light glazing. The vaulting at all other points is solid and with the side walls is set with enameled tile arranged to conform to a general decorative scheme in green and white peculiar to this station. The details of the vault construction are clearly shown by the drawings of Fig. 29. Where the loop passes under the

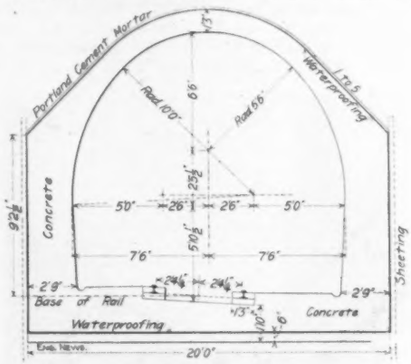


Fig. 28. Special Concrete Tunnel Section for City Hall Loop.

spur tracks the semicircular structure shown by Fig. 28 is replaced by a rectangular section of steel beams and corrugated iron roof filled with concrete.

The second of the 17 contract sections begins at Chambers St., extends up Center St. to Reade St., and then curves west along New Elm St. to Elm St., which it follows to Great Jones St., its terminus. A portion of this section is shown by Fig. 27. The construction throughout this sections, except at two points, will be the standard four-track subway structure. The two points where a variation from this standard structure will be made are between Grand and Broome streets, where a fifth track for switching purposes will be installed, and between Broome St. and Pearl St., where the nature of the subsoil makes it likely that a special foundation will be required. To provide for the fifth track between Grand and Broome Sts., the columns between which this track comes were spread apart from the standard 12½ ft. to 22 ft., and the space was spanned by special roof girders 3 ft. deep. There are four local stations on Contract Section II.

METHODS OF WORK.—The methods of work adopted in constructing the subway line on Contract Sections I. and II. varied with the surface conditions, the depth below the surface and the nature of the underground structure. They will be best understood, perhaps, by considering each separately, and reference will be made first to the City Hall loop line. This loop passed entirely underneath the vaults of the post-office and below the vaults of the Times Building, a ten-story structure. The portion passing under the post-office vaults and Mail St. was at a depth of 40 ft. below the surface. The portion of this loop lying outside of the boundaries of the four-track subway down Park Row was open-cut tunnel work. A single trench was dug the full width and depth required for the concrete tunnel structure, and the walls of this trench were supported by vertical sheeting held by horizontal waling timbers, between which stout timbers were inserted across the trench. Where the loop passed under the post-office and Mail St. tunneling was resorted to. The vaults were held up by shores, and both they and the surface of Mail St. were kept intact for the receipt and despatch of mail as usual. At the bottom of the timbered trench the concrete foundation was placed in 4-in. layers, the side walls carried up in forms, and the roof arch built on centers. As the concrete work progressed to the proper points the waterproofing layer was placed, using the materials and methods of construction described in a preceding article. The excavation was entirely in soft, loamy soil and sand, and neither it nor the backfilling call for particular mention. The excavated material was hoisted by stiff-leg derricks operated

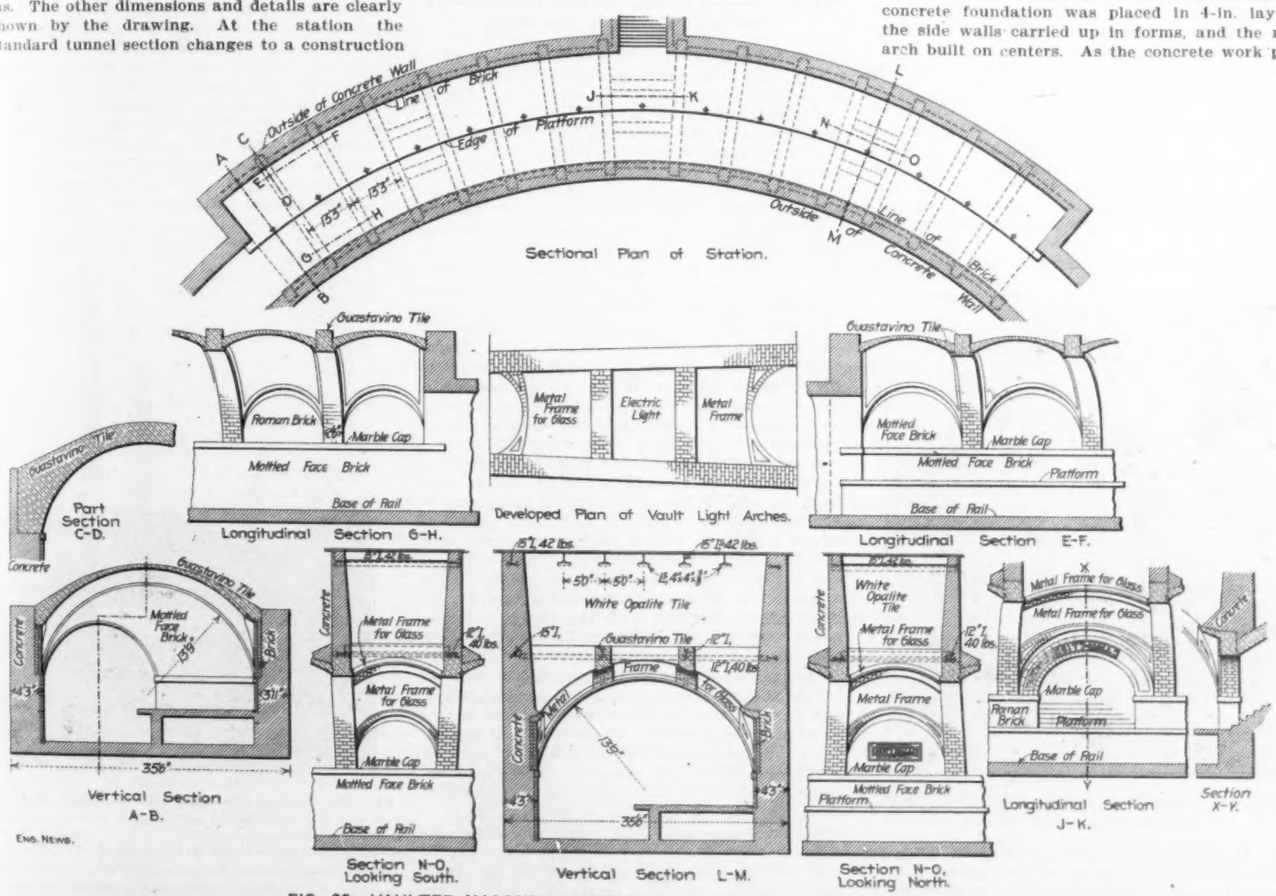


FIG. 29. VAULTED MASONRY STATION CONSTRUCTION ON CITY HALL LOOP.

consisting of side walls of concrete carrying a vaulted roof of Gustavino arches, as shown by Fig. 29. The station, as will be observed, has a single platform connecting with the street level by by a stairway from near its center. At three points, as will be seen, the station roof is of glass, and light walls extend to the surface and are covered

by compressed air. The excavated material was removed as it was taken out, and backfilling was made with earth brought in as needed.

The portion of the work comprising the spur line down Park Row and the main line up Center St. to Reade St., formed a special problem owing to the fact that the street surface was largely occupied by conduit electric railway tracks carrying a very heavy traffic. These surface tracks had to be maintained and the traffic kept unobstructed during the construction of the subway. To accomplish this the following plans were resorted to:

Along Park Row and Center St. to Chambers St. a narrow trench was dug at each side of the surface tracks, and in the plane of the sidewalls of the subway structure. When these trenches were deep enough to clear by 6 or 7 ft. the bottom of the surface railway conduits and foundations, a series of horizontal galleries were carried between them transversely across the street underneath the tracks. These galleries were so located as to come between the wall columns and roof beams of the subway bents. Each transverse gallery was timbered as much as was necessary to permit excavation, and when completed a 14 × 14-in. timber, called a "needle," was placed against its roof and supported by short struts resting on the floor. The next step was to sink from the floor of the gallery 6 × 6-ft. shafts deep enough to clear the bottom of the foundation bed of the subway structure. There were generally six of these shafts in each gallery. In these shafts were set 12 × 12-in. columns or posts solidly founded at the bottom of the shafts, and having their tops wedged firmly against the roof beam or "needle." The "needle" itself was firmly wedged against the under surface of the track structure. As soon as the columns were placed the short struts holding the "needle" were removed and the columns took the entire load. The transverse galleries were excavated about 10 ft. apart, and when ten, say, had been completed, the contractor had about 100 ft. of track carried by ten timber bents founded well below the deepest future excavation. With these main supports it was then simply a matter of careful work to remove the remaining earth and timber the excavation, after which the subway structure was erected.

Along Center St., between Chambers and Duane

Fig. 31. Head-Tower and Dumping Platform of Lidgerwood Cableway.

Sts., the plan adopted was to dig a rather wide trench at one side of the street and to tunnel from it transversely across the roadway underneath the surface tracks. Needle beams and columns were placed as described in the preceding paragraph. From Duane St. the subway curves west into New Elm St., and as there is but little street traffic at this point it was possible to open up a single wide trench the whole breadth of the street. From this point north one-half of the street was opened at one time, and the structure completed, after which the other half was opened. Fig. 30 is a view on Elm St. showing the trench occupying one-half the width of the street. The general method of timbering all trenches was to use a vertical sheeting held in place by waling timbers and cross braces. The principal difficulties encountered were due to the adjacent building foundations, many of which had to be underpinned, and to the subsurface pipes for gas, water, etc. Along Elm St. the excavation passed close to the buildings, and from 10 to 15 ft.

Fig. 30. View on Elm St., Showing Trench Occupying Half the Width of the Street.

below the foundations of many of them. A 36-in. water main and a 30-in. gas main formerly in the street had to be relaid outside of the subway walls, generally under the sidewalks. Other pipes, especially at street crossings, had to be relaid in the much diminished space between the street surface and the roof of the subway. These pipes had all to be supported by timbering or hung by chains from the trench timbers during excavation.

The excavated earth was handled by derricks and cableways. Along Park Row narrow-gage tracks were laid in the cross galleries. The earth from the center of the excavation was carried in push-cars on these tracks to the side trenches and there lifted by the derricks or cableways and dumped into wagons. Fig. 30 shows the cableways on the Elm St. work, and Fig. 31 shows the dumping platform for one of the cableways, with the wagon standing underneath. The cableways used were supplied by the Lidgerwood Manufacturing Co., of New York city. There were two plants, duplicates in all respects, each being designed for a span of 425 ft., and a load of three tons, the material being handled in large tubs of about 45 cu. ft. capacity. The head tower, as shown in Fig. 31, was of the four-post type, with car, on which was mounted the hoisting engine and boiler. The main cable was attached by means of a split anchorage connection to the back end of the car, and the tower was also guyed from the top to the back end of the car. The car and tower were held in place by two anchor ropes attached from the timber at the rear end of the car platform to deadmen anchorages, and were so arranged that they could be moved forward or backward in the direction of the cable, either on truck wheels or skids, as the work progressed. The tail tower was merely an A-frame about 40 ft. high, and the main cable at this end was carried back some distance to a deadman anchorage. The hoisting engine was a Lidgerwood double 9 × 10-in. cylinder engine, with double tandem friction drums 33 ins. in diameter and all operating levers in a rack at the rear. The main cable was 1¾-in. cast steel; the carriage was the regular Lidgerwood three-wheel carriage, and the regular Miller fall-rope carriers were used. The engine was operated by compressed air most of the time.

The manner in which the subway structure was built varied somewhat with the manner in which the excavation was accomplished. Along Park Row and in other places where the excavation was carried laterally underneath the street surface from side trenches, the mode of procedure was as follows: The foundation and floor of the subway were first built in concrete, and on this the steel bents were erected. The concrete side-wall arches were then built in forms between and enclosing the wall columns. Next, the roof arches were built on portable centers. On this roof brick piers were erected to hold up the surface car tracks while the needles were being removed. Finally, the space between the subway roof and the supported street car tracks was filled with carefully-rammed earth. Where the trench was opened the full width of the street the erection of the subway structure was simple straightforward work. Where one-half of the street was opened at one time, the practice was to complete one-half of the subway structure and then refill the trench before building the other half and connecting the two.

The only mechanical plant used in the building of the subway structure were derricks for handling the steel-work, pneumatic riveters and hammers and concrete mixing machines. These machines were all operated by compressed air. The concrete mixers used were built by the Ransome & Smith Co., of Brooklyn, N. Y. They had a capacity of 200 cu. yds. of concrete per day, and were operated by a 10-HP. vertical engine using compressed air.

POWER PLANT.—There being no rock excavation on Contract Sections I. and II., drills were not used, but a complete compressed air power plant was installed to supply air for operating the pneumatic tools, hoisting engines, concrete mixers, etc. This plant was located on a triangular area of land at the junction of Reade St., Center St. and City Hall Place, and Fig. 32 is a general view of the building. This building is divided into a boiler room, containing two 100-HP. and two 150-HP. horizontal boilers, arranged two in a battery, and into an engine room containing two 24 × 24¼ × 30-in. straight-line Ingersoll-Sergeant air compressors. Each battery of boilers has an independent stack, and supplies steam at 100 lbs. pressure to one of the compressors. In the boiler room there are two feed pumps, a

Fig. 32. Central Compressed Air Power Plant for Sections I. and II.

feed-water heater and a blow-off tank. The compressors are cooled by water from the city mains which is discharged from the jackets into a tank and used for boiler feed. They deliver air at 100 lbs. pressure to a 4 × 12-ft. receiver, having an 8-in. outlet to the street, from which a 6-in. pipe extends south, and a 5-in., decreasing to 4-in., pipe extends north along the work. From these supply pipes air is tapped to the machines scattered along the work. In cold weather the air was reheated before using.